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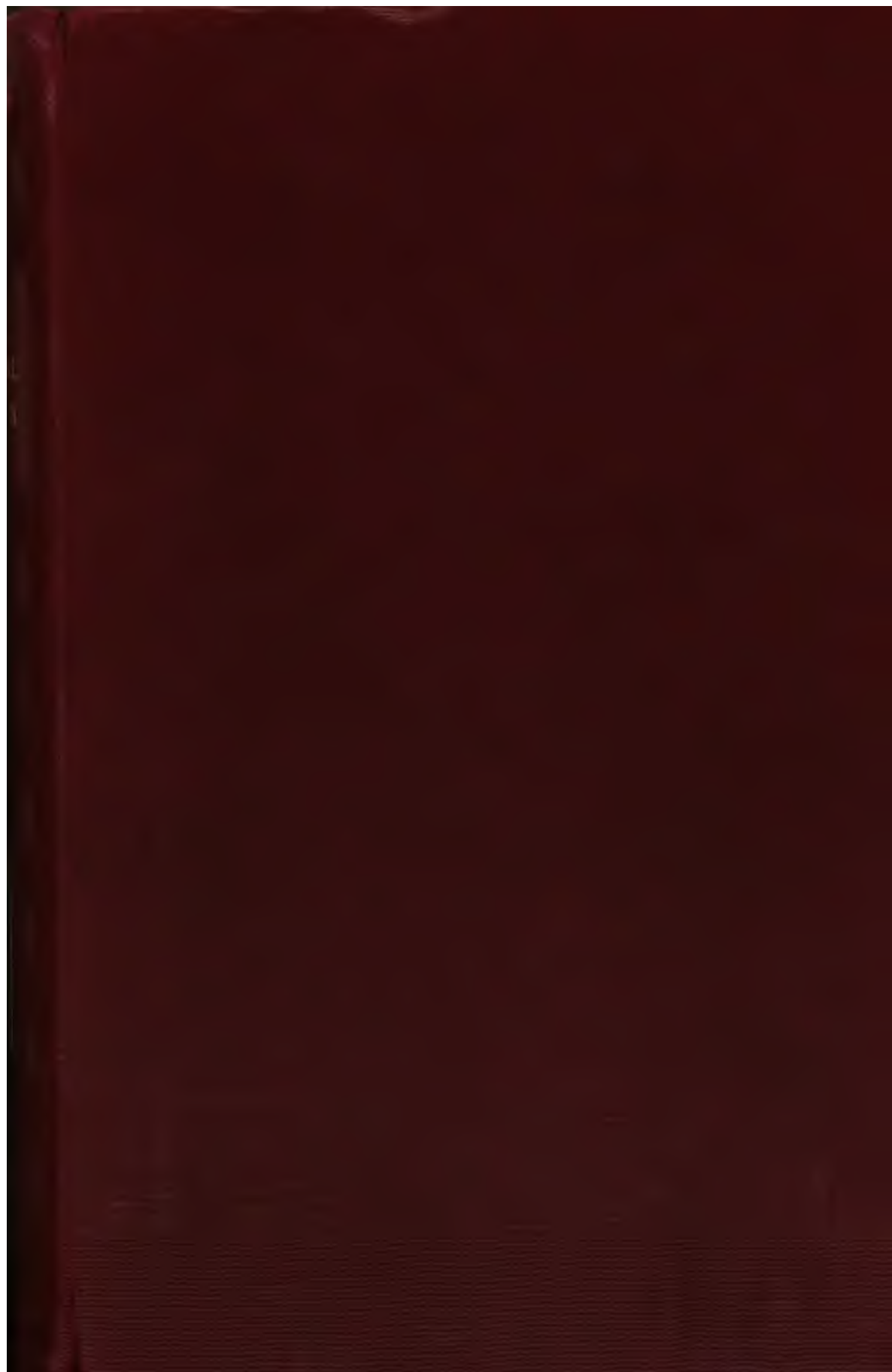
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INVESTIGATION
OF
PANAMA CANAL MATTERS.

TESTIMONY OF ENGINEERS
BEFORE THE
COMMITTEE ON INTEROCEANIC CANALS
OF THE
UNITED STATES SENATE

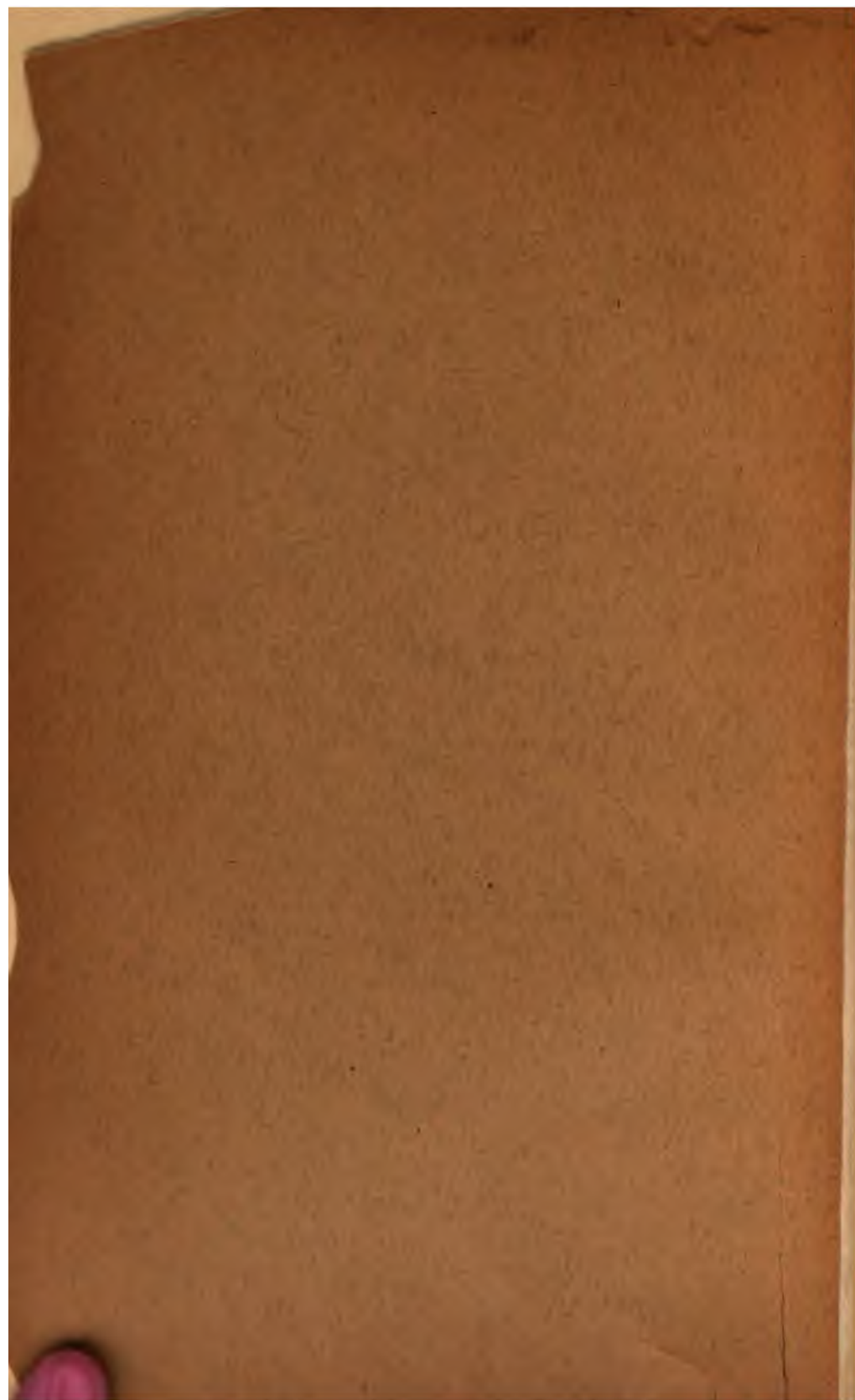
IN THE MATTER OF THE SENATE RESOLUTION
ADOPTED JANUARY 9, 1906, PROVIDING
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PANAMA CANAL,
ETC.

MEMBERS OF COMMITTEE:

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THOMAS C. PLATT, OF NEW YORK.
ALFRED B. KITTRIDGE, OF SOUTH DAKOTA.
JOHN F. DRYDEN, OF NEW JERSEY.
ALBERT J. BOYKIN, OF ILLINOIS.
PHILANDER C. KNOX, OF PENNSYLVANIA.

LEVI ANKENY, OF WASHINGTON.
JOHN T. MORGAN, OF ALABAMA.
EDWARD W. CARMAICK, OF TENNESSEE.
JAMES P. TALLAFERRO, OF FLORIDA.
ARTHUR P. GORMAN, OF MARYLAND.
F. M. SIMMONS, OF NORTH CAROLINA.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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Report of the Engineering Committee of the Isthmian Canal Commission, dated February 14, 1905, is appended to this volume.

STATEMENT OF JOHN F. STEVENS,
CHIEF ENGINEER,
BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Tuesday, January 23, 1906.

The committee met at 10.30 o'clock.

Present: Senators Millard (chairman), Kittredge, Dryden, Hopkins, Ankeny, Morgan, Gorman, and Simmons; also John F. Stevens, esq., chief engineer of the Isthmian Canal Commission.

FURTHER STATEMENT OF JOHN F. STEVENS, ESQ., CHIEF ENGINEER OF THE ISTHMIAN CANAL COMMISSION.

Senator MORGAN. If the chairman will permit me, I will ask Mr. Stevens a few preliminary questions to open up the subject before he makes his statement.

The CHAIRMAN. Go ahead, Senator.

Senator MORGAN. You have read this minority report, Mr. Stevens?

Mr. STEVENS. Yes, sir.

Senator HOPKINS. Will you let me interrupt you one moment, Senator?

Senator MORGAN. Yes, sir.

Senator HOPKINS. Would it not be better for Mr. Stevens to give us a summary of the majority report and a summary of the minority report, to point out the strong points in the majority report and the strong points in the minority report, and state where they agree and where they disagree.

Senator MORGAN. That will be the course of the examination. I will ask Mr. Stevens but a very few questions leading up to that.

Senator HOPKINS. All right. I simply suggested that, with a view of helping the members of the committee who have not made a critical examination of the reports to understand the matter.

Senator MORGAN. I see that the minority brings forward a specific plan for a lock canal and recommends it. In some respects it is a new departure, particularly as to building the dam at Gatun and the locks in the hills back of Gatun. Are those hills on the right or the left bank of the Chagres River?

Mr. STEVENS. On the right bank.

Senator MORGAN. How far back of Gatun are they?

Mr. STEVENS. They are immediately at Gatun.

Senator MORGAN. Right at the place itself?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Gatun is a little village there?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Have you examined, I may say critically and as an engineer, the various other propositions for a lock canal at Panama? Have you examined the various other propositions for a lock canal there?

Mr. STEVENS. I have known of several other propositions. I have, of course, examined the ground that would be involved in their construction.

Senator MORGAN. Have you examined any of those plans or proposed plans with a view of the possibility of their being adopted by the committee?

Mr. STEVENS. I never have seen any detailed plans; no, sir.

Senator MORGAN. You have not seen any?

Mr. STEVENS. No, sir.

Senator MORGAN. So that in speaking about this particular plan that is brought forward by the minority of the committee, you do not propose to exclude the consideration of all other plans for a lock canal and to adhere to this particular one as the basis for your recommendations?

Mr. STEVENS. I do not quite understand you.

Senator MORGAN. Here are several plans that have been brought forward by engineers of merit, note, ability, some of which have been submitted to the Commission and some of which have not, of which you may have some knowledge; I do not know. In the statement that you propose to make before the committee, do you propose to say that you reject any and all plans except the one recommended by the minority for a lock canal?

Mr. STEVENS. No, sir; I do not mean to say that.

Senator MORGAN. You do not mean to say that?

Mr. STEVENS. No, sir.

Senator MORGAN. So that in the examination of this proposed plan gotten up by the minority of the committee you will contrast that with the sea-level canal?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And upon that basis, I suppose, our examination with reference to this will be conducted, it being understood that if, for instance, a lock-canal plan should be adopted it would not be necessarily this plan. The committee would feel at liberty, and the Congress would feel at liberty, if they found a plan that they believed was better than the one suggested here by the majority and the one suggested by the minority, to investigate it; and we would simply confine ourselves to the consideration of the question as to whether this shall be a sea-level canal or a lock canal, upon the predicate of the report of the majority in favor of a sea-level canal and of the minority in favor of a special plan for a lock canal. That was what I wanted to get at; I wanted to have an understanding about that.

The CHAIRMAN. I do not understand that this is binding upon the committee at all; it is simply for general information.

Senator MORGAN. I will venture to say to the committee and to Mr. Stevens, too, that I think there is at least one plan that may be brought forward that I think is quite superior to the plan proposed by the minority of the committee. I do not know that it will be brought forward, but it may be; and I merely wanted to suggest that if we recommend the adoption of the minority report it should be done with reference simply to the choice between a sea-level and a

lock canal, leaving ourselves open as to a method of construction coming from other sources that might be considered better than this.

Senator HOPKINS. Now, Senator, if Mr. Stevens can now give us a summary of the two reports we will be able to get a more intelligent view of the situation, and we can then examine him with reference to any suggestions that he may have to make in favor of either the majority or the minority report.

Senator MORGAN. That is exactly what I desire on my part; and I merely made these preliminary observations to keep the subject clear in our minds.

The CHAIRMAN. Now, Mr. Stevens, will you proceed?

Mr. STEVENS. Mr. Chairman, I am afraid that Senator Morgan's ideas of my responsibilities in this case do not quite accord with mine. When I came to the Canal Commission as chief engineer there was a delimitation made in the duties of my office, it seemed to me. The powers appointed a board of consulting engineers, to take practically all the time they required, and to have all the assistance they required, to investigate all of these propositions; and presumably their report, when made, would be seriously considered, if not adopted. They were the people to thrash out all of the details; and the consensus of their best judgment was the best that the committee or the President could obtain. Therefore that took from me, in a very large measure, my responsibility in regard to this question; and I have always regarded, and still regard, myself not as a man directly responsible for these reports—either of them—even if I should favor one over the other, or if I should favor something entirely different.

Senator MORGAN. I, for one, am very glad that you feel yourself entirely free from responsibility for these reports, and that you have a free hand to make any observation that you choose to make or think it proper to make in regard to either of them.

Mr. STEVENS. More than all that, when the consulting board were down there in September, I think, I came before them and they questioned me very closely about my predilections and my ideas about the matter. I told them (which was very true) that I had only been there a couple of months, and, as everybody must know, my time was taken up with other very important things.

Senator MORGAN. But you were there during all of that time?

Mr. STEVENS. I was there all of that time, but I had nothing whatever to do with the consulting board. I made only one or two trips with them, and they were left free to gather information from any source they chose. What I want to bring out is this fact—that I do not consider myself responsible for the investigations and the conclusions that have been drawn by anybody.

Senator MORGAN. No; nobody, I think, regards you in that light.

Mr. STEVENS. And in my capacity now I only claim that I act as an adviser of the Commission—to give them my ideas. My ideas may not be any more valuable than those of anyone else who has been there the same length of time.

Senator MORGAN. That is exactly what we consider you—the adviser of the committee.

Mr. STEVENS. In other words, I was not engaged as chief engineer to tell the Commission or the country or anyone else what kind of a canal should be built. They took other means.

Senator KITTREDGE. What did you understand your duty to be?

Mr. STEVENS. To build the kind of canal that was chosen to be built, to carry out the details of the work, and to see it built.

Senator HOPKINS. You expected to have some considerable voice in determining the character of the canal that you were to build, however, did you not?

Mr. STEVENS. I supposed, of course, Senator, that my advice would be asked, as it has been; yes.

Senator DRYDEN. You are prepared to give the committee the benefit of your judgment in this matter?

Mr. STEVENS. Certainly; certainly.

Senator GORMAN. I think Mr. Stevens had better go on now and make his statement.

Senator MORGAN. I want to call Mr. Stevens's attention to just one fact before he starts. I notice that in the majority report and also in the minority report the canal is projected (both the sea-level and the lock canals) so as to enter the Bay of Limon almost north, I will say, from Gatun; and they both seem to eliminate that part of the canal that leads through Colon.

Mr. STEVENS. Yes, sir.

Senator MORGAN. So that I think we perhaps need not pay much attention to the situation there in comparing the two routes. They both agree that the canal should go into the Bay of Limon on nearly a straight line.

Senator GORMAN. But, Senator, as this testimony of Mr. Stevens is going in by way of an explanation of this matter to everybody in the Senate, had he not better go on in his own way now and describe the two plans? There may very likely be other Senators who do not know anything about them.

Senator DRYDEN. Yes; and I am one of them. I am sure I would be entirely at sea without the benefit of Mr. Stevens's explanation.

The CHAIRMAN. Mr. Stevens, you may proceed now and give the committee your judgment in regard to these matters. I think perhaps it would be well for you first to describe the two proposed plans, commencing with the majority report.

Mr. STEVENS. I imagine that any explanation I might make would be very blind if I undertook to give a graphic description in words here in the most general terms, without any preparation of the two plans, unless some one should ask me questions to bring out anything that might be desired.

The CHAIRMAN. We will ask you the questions when you are through, Mr. Stevens; you will be asked questions then.

Mr. STEVENS. The plan reported by the majority of engineers contemplates what is called a sea-level canal, extending from a point about midway in the front of the so-called harbor at Limon.

Senator KITTREDGE. Would it be embarrassing to you for me to ask a question at this point?

Mr. STEVENS. Not at all.

Senator KITTREDGE. Where would that be with reference to the Mindi River?

Mr. STEVENS. About opposite the mouth of the Mindi River, where the river debouches from the marshes.

Senator MORGAN. By the qualification "so called," that you put in your remark, you mean that neither of them is strictly a sea-level canal—a canal without locks.

Mr. STEVENS. I understand not; no, sir. A tidal lock will be necessary even in the case of a canal at sea level. You see these reports are both incomplete, in that the consulting board have never submitted any plans, either of the alignment or of anything else. They have submitted merely the bare report, and the only thing we have to judge from is that report. [Referring to large map in committee room:] Here is Gatun; here is Mindi, Boca Mindi (Boca means mouth), the mouth of the Mindi River. The Little Mindi River comes in here.

The present line of the canal as the French excavated it runs through here to Cristobal, which is here, Colon being on Manzanillo Island. The old line of the canal described this reverse curve of which we spoke the other day. The Bay of Limon, to continue the shore line, runs around here to a point called English Point, right here, which is about two and a half miles directly across from Manzanillo Island or Colon. This bay, so called, might in fact be called an open roadstead. It has no protection whatever. The north is here—here is the north point; so that the prevailing heavy winds, which we call the “northers” (which really come from a few points west of north), sweep directly into this bay, and it affords no protection whatever for shipping during the continuance of the “northers.” The point brought out the other day by Senator Morgan’s question as to which I preferred, whether it would not be safer to have the entrance straight in here instead of making that curve, is illustrated on that map. Perhaps I am digressing, however. I ought not to do that. Shall I go on?

Senator HOPKINS. Yes; go on.

Mr. STEVENS. A ship coming in with the wind astern would follow the direction of that ruler. [Pointing with ruler on map.] When she got here she would have to turn nearly at right angles, which would bring her, before she got to the protection of this point, with the wind abaft—with the wind crosswise, to use a landsman’s term—which of course would affect her steerageway in getting into the canal. Those considerations no doubt influenced the board in recommending in both the majority and the minority reports a straight entrance, in one case, as I understand, leaving the present line of the canal (this being the canal) about at this point, so as to make an easy curve here, and going straight through this point out to sea, something like that. [Indicating.]

Senator KITTREDGE. Which report are you now referring to, Mr. Stevens?

Mr. STEVENS. That is the recommendation of the majority report, cutting through this island here. The other report leaves at about the same point, but swings outside of the island, and then with a slight curve opposite goes to nearly the same entrance. The reason the minority report changes the line through here is to save what they call a large amount of rock excavation in the channel, which extends through this point here. By going outside they miss it completely. That is the reason, as I understand the reports, why they are not exactly on the same lines from here to here. [Indicating.] While in effect, to my mind, they are practically the same, there is a slight change in the alignment between the minority and the majority reports. Both reports have estimated breakwaters running from here outside of the line of the canal to prevent the cross winds from filling

in this deep channel through here. That is all the difference that I know of, as far as the line of the canal is concerned, at the southern terminus.

Senator MORGAN. Would that breakwater meet a "norther" squarely, or would it come in obliquely?

Mr. STEVENS. Endwise; practically endwise. A vessel entering the channel by the canal built according to either report would have a wind dead astern so as to have a straight shoot into the channel. As I understand the object of this breakwater, it is not for the protection of the ships—we do not think they need it—but for keeping this lateral drift of currents from closing up the channel.

Senator HOPKINS. How much excavation through that island does the minority report save?

Mr. STEVENS. That I could not tell you.

Senator HOPKINS. You do not know how many cubic feet or yards of excavation will be saved?

Mr. STEVENS. My impression is that it is in the vicinity of a million yards, although I would not undertake to say accurately. Indeed, I have not had access to their figures; I do not know.

Senator HOPKINS. And what is the character of the rock there? Are you sufficiently familiar with it to have an independent knowledge?

Mr. STEVENS. Why, it is a heavy coral rock, very hard as to blasting.

To go along with the sea-level project, I think they follow the same line right through, with a 40-foot channel of varying widths. I have a table there which gives the comparison of widths clear through to the south end.

Senator HOPKINS. Both reports follow the same route?

Mr. STEVENS. Yes, sir; yes, sir; until you reach the Pacific end.

Senator HOPKINS. Yes.

Mr. STEVENS. If you will allow me to look now at this end, this line here shows the location of the canal as proposed and as partially constructed by the French. You can see the small railroad yard at the little town of La Boca back here, and at this point there is a steel dock, which belongs to the railway company. Here is La Boca; here are the railroad yards, the swerve coming off of the main line of the railway. Here is Panama, and the little steel dock, as long as my finger, is shown very small on this plan. This high mountain here is what is known as Ancon, and this one is Sosa.

The majority report favors doing this: Leaving the present line near Miraflores (Miraflores is here), and coming straight through the marshes here, crossing from the high ground shown at this point, which is largely rock, and passing between Sosa and Ancon, at sea level throughout, making, I believe about here, a slight angle; then running out to the 40-foot contour in the harbor, or the 7-meter contour, at about this point, placing one lock here at Miraflores, where my finger is.

Senator GORMAN. That is the tide lock; that is the only lock?

Mr. STEVENS. That is the tide lock.

Senator GORMAN. How far inland is that from the present harbor?

Mr. STEVENS. That would be about $8\frac{1}{2}$ miles from the ocean contour line, the 40-foot line; about 4 miles from La Boca. The minority report makes a change commencing at about the same point, and

comes through there, as indicated by pencil, like this: Leaving here, south of Miraflores, coming through and touching the side of Ancon Hill here at La Boca, then coming on and connecting with the present line of the canal out here in the harbor, and taking that line through.

Senator KITTREDGE. What plan contemplated the alignment indicated on the map?

Mr. STEVENS. There is no plan that is reported on that contemplates exactly that alignment. That is the old French plan. It was the old Commission plan; it was the De Lesseps plan; it was the plan of the second French company; and all the work that has been done on the west or south side has been done on this line.

Senator GORMAN. Where is the first lock, in the minority plan, on the Pacific side? How far is that?

Mr. STEVENS. The minority plan proposes to put a dam across the valley as I have indicated there, crossing the Rio Grande just here [indicating]; that is the Rio Grande; another one from Sosa marshes across to Ancon; and still another across from Ancon to the high ground here shown, which is right there [indicating]. That dam, I understand, is to raise the water to an elevation of 55 feet, and the proposed plan places two locks where I have indicated here.

Senator GORMAN. At Ancon Hill?

Mr. STEVENS. At Sosa Hill, that being a rock foundation, and another lock at or near Miraflores. The effect is that with these dams and these locks here there will be a certain area, estimated at about 8 square miles, going around here inside of these dams, which will become a lake with an elevation of 55 feet, and then from Miraflores on.

Senator GORMAN. How much lake navigation would that give between those series of locks—the locks at the dam and the others?

Mr. STEVENS. About 4 miles.

Senator KITTREDGE. The lock at Miraflores is 30 feet high?

Mr. STEVENS. The lock at Miraflores, I understand, is about 30 feet high; yes, sir.

Senator MORGAN. This is all stated in the minority report.

Senator GORMAN. Yes; I wanted to get it, though, for my own information. About what would be the elevation of Sosa above the level of the lake, which has an elevation of 55 feet?

Mr. STEVENS. The top of Sosa Mountain?

Senator GORMAN. Yes.

Mr. STEVENS. Sosa must be 350 feet above the ocean, so that it would be in the neighborhood of 300 feet above the lake.

Senator GORMAN. Is Ancon as high as that?

Mr. STEVENS. Very much higher. Ancon, as I recollect, is about 600 feet high.

Senator KITTREDGE. What is the length of the three dams that you have mentioned?

Mr. STEVENS. In the aggregate?

Senator KITTREDGE. The one at La Boca, the one across to Ancon, and the one from Ancon over to this other place on the Panama Railway.

Mr. STEVENS. I would have to trust to my memory for that.

Senator KITTREDGE. About what is it?

Mr. STEVENS. I should say this dam here would be about three-quarters of a mile long; that one would be something less than a half

a mile, and the one across here would probably be about a mile or a mile and a quarter—possibly longer.

Senator MORGAN. What is the width of the depression between Sosa and the other mountain?

Mr. STEVENS. Not much over a quarter of a mile.

Senator MORGAN. About what is the elevation of the canal above the level of the sea?

Mr. STEVENS. I should say about 8 or 10 feet.

Senator MORGAN. Only eight or ten?

Mr. STEVENS. Yes, sir.

Senator SIMMONS. You mean the space between Ancon and Sosa?

Mr. STEVENS. The distance from here to here [indicating on map].

Senator KITTREDGE. I did not hear the character of the dams that the minority report recommends.

Mr. STEVENS. Earthen dams throughout.

Senator MORGAN. That canal will go through a valley between the two mountains?

Senator SIMMONS. Ten feet above the sea level?

Mr. STEVENS. Ten feet is probably an exaggeration, Senator; I would say 6 or 8 feet.

Senator MORGAN. Above mean sea level?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Let me ask you just one question there. At high tide does the tide run in between those hills?

Mr. STEVENS. No, sir.

Senator MORGAN. It does not?

Mr. STEVENS. But it does, at extreme high tide, go over these flats.

Senator KITTREDGE. Through the valley of the Rio Grande?

Mr. STEVENS. Through the valley of the Rio Grande; yes, sir.

Senator GORMAN. How much of the old French work is abandoned by the minority plans? They did a great deal of work at that end, did they not?

Mr. STEVENS. Well, yes, sir; the minority plan abandons about four miles.

Senator SIMMONS. The majority plan abandons about 8 miles?

Mr. STEVENS. About 8 or 8½. Now, at the other end, the proposition of the minority is to build a dam across from high ground to high ground here [indicating], something after this shape, through here [indicating].

Senator KITTREDGE. That is in the neighborhood of Gatun?

Mr. STEVENS. Yes, sir; and through here. As I remember, the dam is about—well, say, in round numbers, 7,000 feet—a mile and a quarter, possibly a mile and a half, from end to end, and 135 feet high.

Senator KITTREDGE. Of what material is that dam to be constructed?

Mr. STEVENS. Of earth. The elevation of water proposed is 85 feet, which would leave the crest of the dam 50 feet above the top of the water.

Senator KITTREDGE. Is that the only dam on the northern side of the canal?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. They abandon the dam at Bohio?

Mr. STEVENS. Yes, sir; yes, sir. Instead of making two dams, I believe, as has been suggested, they make it all in one.

Senator MORGAN. That dam would raise the level of 85 feet to Miraflores?

Mr. STEVENS. To Miraflores; yes, sir.

Senator MORGAN. Clear across the whole lake?

Mr. STEVENS. Yes, sir.

Senator GORMAN. Clear across the ridge?

Mr. STEVENS. Yes, sir.

Senator GORMAN. Mr. Stevens, what sort of a foundation have they for this proposed dam?

Mr. STEVENS. They have clay—a mixture of clay. Generally speaking, it is clay down to different depths from 20 to 200 feet. Then they strike what they call indurated clay, of which we spoke the other day, which is to all intents and purposes rock. My opinion—I presume you will ask it—is that this clay is impervious.

Senator KITTREDGE. The clay is impervious?

Mr. STEVENS. I think it is; about.

Senator GORMAN. Does the difference between the majority and the minority relate to the safety of that foundation—the very serious difference of opinion there?

Mr. STEVENS. The majority report, as I remember it, does not favor building a high earth dam on that foundation. The minority report does. I think there is a clear division of opinion, although, of course—

Senator SIMMONS. How high did you say that dam was?

Mr. STEVENS. 135 feet high.

Senator GORMAN. But to go down to the foundation?

Mr. STEVENS. It is 200 feet, at some points, to solid rock.

Senator KITTREDGE. How deep does the minority recommend that the foundation shall be laid?

Mr. STEVENS. The minority recommends simply taking off the detritus at the top and building the dam directly on this impervious clay.

Senator KITTREDGE. And how deep is that below the surface?

Mr. STEVENS. Oh, I suppose, probably from 10 to 12 or 15 feet.

Senator GORMAN. Not more than that?

Mr. STEVENS. Not more than that; they recommend simply taking off the accumulated vegetation, Senator, you might say.

Senator MORGAN. Mr. Stevens, as I understand it, a vital point in this canal in which the majority and the minority concur is as to building a dam at Gamboa to create a great lake to lie back of it?

Mr. STEVENS. Yes.

Senator MORGAN. That would create a great lake to lie back of Gamboa, without any regulation plan connected with that dam, so far as I know, to control the flow of water into the canal?

Mr. STEVENS. I do not understand it quite that way. A reference to their report will show that. My understanding is that the majority report proposes to build a dam across at Gamboa about where my thumb is; this being the line of the canal [indicating].

Senator KITTREDGE. That is where the Chagres River enters the canal?

Mr. STEVENS. Where it first strikes the valley which the canal follows.

Senator MORGAN. That is for purposes of protection?

Mr. STEVENS. That is to hold the flood waters of the Chagres back until they can be drawn off by means of regulating works built in the dam.

Senator MORGAN. In the dam?

Mr. STEVENS. Yes.

Senator MORGAN. Very well; then I was mistaken about that. Now, therefore, the point is that the sea-level men want to protect the canal against the Chagres River by regulation works put in the dam?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And to hold the water back against floods, consecutive floods, etc., for that purpose—for protection?

Mr. STEVENS. Yes, sir.

Senator MORGAN. The minority plan contemplates a lake from Gatun to Miraflores?

Mr. STEVENS. Yes, sir; from this point; from Miraflores, over here.

Senator MORGAN. What do they propose to do with the flood waters behind that dam?

Mr. STEVENS. They do not propose to build any dam.

Senator MORGAN. No dam at all?

Mr. STEVENS. No, sir.

Senator MORGAN. Now I have got it straight in my mind, then.

Mr. STEVENS. The elevation of the ground or the bed of the river at Gamboa, at the site of the proposed dam, is within a foot or two of 50 feet. If you flood this country here to an elevation of 85 feet, it follows that you have 35 feet of water, with a lake, at the Gamboa dam site. That water, which is dead water, will flow north about as far as Alhajuela.

Senator GORMAN. What distance is that?

Mr. STEVENS. By the river it is 10 or 11 miles; the valley line, of course, is the line you have to figure on in the dead water. It is the expectation that the flood waters would have no effect whatever on the canal, having, we will say, 7 or 8 miles of dead water between the canal and the limit of the dead water.

Senator GORMAN. What provision, then, is made for the dry season, when the flow is not sufficient?

Mr. STEVENS. For the canal?

Senator GORMAN. Yes.

Mr. STEVENS. There is enough surface in the lake to allow for fluctuations. For instance, this lake covers, as nearly as I can recollect, 115 or 118 square miles. The board have made very elaborate calculations (based, no doubt, on accurate scientific knowledge) to the effect that the evaporation will be about so much; and, figuring on the number of locks, they estimate that they will use about so much water for putting ships through the locks; so that with an allowance for possible seepage and power at the locks, they estimate that they will have plenty of water to carry them over the dry season, with the addition of that part which comes in. Of course there is always a flow coming in. There are some very large streams, besides the Chagres, above Gatun, which will necessarily come into the lake. They have made very elaborate calculations there, which may or may not be correct.

Senator MORGAN. Do the minority propose to put in a dam at Alhajuela?

Mr. STEVENS. Not at present; no, sir.

Senator MORGAN. Nor at Gamboa?

Mr. STEVENS. Nor at Gamboa. They propose to put in no dams whatever for storage purposes.

Senator MORGAN. That is the only dam they put in until they get away over here [indicating]?

Mr. STEVENS. Yes, sir.

Senator MORGAN. I would like to ask your opinion, Mr. Stevens, as to whether water standing 35 feet deep in this lake (which runs clear through, as we understand) will resist the flow of the Chagres River to such an extent as to prevent the lock canal from being torn up by the power of the Chagres River? Here comes the Chagres River down from the mountains with a tremendous flood—a 40-foot flood, we will say; that has occurred. That 40-foot flood pouring in upon a 35-foot elevation in the lake will of course sweep it out?

Mr. STEVENS. With 7 or 8 miles of dead water, my opinion is that it would lose its force before it got to the canal. That is my opinion.

Senator MORGAN. If it was 40 feet high?

Mr. STEVENS. It never comes in one wave 40 feet high, Senator. That is distributed over a number of hours.

Senator MORGAN. Yes; over a number of hours—about twelve.

Mr. STEVENS. It is not like a dam going; it is not like the Johnstown flood, for instance. Nothing of that kind ever has happened.

Senator MORGAN. I was about to suggest this: Do you think it would be advisable to make an estuary at Gamboa for the purpose of containing any possible flood of that sort that might come down, say to the eastward of Gamboa?

Mr. STEVENS. My opinion is that it would be unnecessary. Of course it would be an additional insurance.

Senator MORGAN. Yes.

Mr. STEVENS. But you must understand that the canal is quite wide at this point. My recollection is that at Gamboa you will have a basin there probably a mile one way and half a mile the other before you get into the course of ships in around here [indicating].

Senator MORGAN. Yes.

Mr. STEVENS. It is not a narrow valley, you understand, by any means.

Senator GORMAN. There is back water in the river, dead water in the river, for 2 miles?

Mr. STEVENS. Oh, for 7 or 8 miles—8 or 9 miles; I do not remember just what the distance is to Alhajuela.

Senator MORGAN. Then this whole question can be finally solved by the engineers and constructors by enlarging the size of that basin in the event that it is found necessary to do so?

Mr. STEVENS. It could be done, but I do not believe that contingency would arise. That is my private opinion.

Senator MORGAN. That is your opinion; that is what we want.

Senator GORMAN. That would practically give you lake navigation three-fourths of the way, then?

Mr. STEVENS. Yes, sir. There is a table here showing those things.

Senator SIMMONS. What is the distance from the point over here

where the dam is to be, at Gatun, as you say, to the other dam? I mean the other dam over here.

Mr. STEVENS. This one [indicating]?

Senator SIMMONS. Yes; the lock dam there.

Mr. STEVENS. From here to here?

Senator SIMMONS. To Gamboa, over here.

Mr. STEVENS. To Gatun?

Senator SIMMONS. To Gatun; yes.

Mr. STEVENS. My recollection is that it is something like 36 miles.

Senator MORGAN. Those distances are given accurately in the report.

Mr. STEVENS. Yes.

Senator MORGAN. Now, on the plan of the minority, all of the affluents of the Chagres River, as well as the Obispo and the Trinidad, are taken care of as to any flood waters by the spillway that is to be erected at Gatun—the Gatun dam?

Mr. STEVENS. That is the minority plan; yes, sir.

Senator MORGAN. They take no care of any streams with regard to backing them over their fountain sources or anything of that sort?

Mr. STEVENS. No, sir.

Senator MORGAN. They let the water run right along, form lakes, and go as high as it will, with the regulation at the Gatun dam?

Mr. STEVENS. Yes, sir. The largest streams generally come in miles from the canal, you know.

Senator MORGAN. I know that.

Senator SIMMONS. Mr. Stevens, you say that would give 35 feet of elevation clear across from this dam to that dam over there?

Mr. STEVENS. That would give something like 75 or 80 feet here until you got up here nearly to Gamboa, in this vicinity, somewhere.

Senator SIMMONS. It would give you 35 feet at the highest point?

Mr. STEVENS. For navigation?

Senator SIMMONS. Yes.

Mr. STEVENS. It would give you 40 feet everywhere.

Senator SIMMONS. Forty feet everywhere?

Mr. STEVENS. Forty feet everywhere.

Senator SIMMONS. Without any excavation?

Mr. STEVENS. Oh, no; oh, no. There would have to be some little excavation, starting in this vicinity; and then, of course, there is the Culebra cut through here.

Senator SIMMONS. That is what I was getting at.

Senator MORGAN. You would have excavation also between Gamboa and Bohio—trimming off?

Mr. STEVENS. Oh, yes; we would have some trimming there.

Senator SIMMONS. If you got 40 feet, how much excavation would there be at these two high points?

Senator HOPKINS. The Culebra cut, for instance?

Mr. STEVENS. The Culebra cut?

Senator HOPKINS. Yes.

Mr. STEVENS. You would have to go to an elevation at the bottom of the canal of plus 45, which would be about, as I recollect it, 160 feet at the deepest point. Here is a profile which was made by the Commission.

Senator KITTREDGE. Which Commission?

Mr. STEVENS. The old Commission; but it happens to illustrate to a certain extent this proposition, with the exception that the dam at

Bohio is indicated on this map. By the present proposition you come down here to Gatun. In other words, this line would be extended through here [indicating]; and this part of the canal, plus 47, is within 2 feet of the proposition of the minority engineers. In other words, everything in red above this line would be taken away.

Senator GORMAN. That is the big cut?

Mr. STEVENS. That is the big cut.

Senator SIMMONS. That is the Culebra cut?

Mr. STEVENS. Yes, sir; and under the minority report the so-called lake navigation will extend from where my pencil is practically through to Bas Obispo, which is here [indicating]; then through cuts of different widths to Miraflores, which is here; then there would be lake navigation from there to what is called Panama La Boca, right here.

Senator SIMMONS. Then this lake plan would reduce that cut how much?

Mr. STEVENS. It would reduce the cut itself from about one—the figures are there exactly.

Senator SIMMONS. 160 feet, you said just now.

Mr. STEVENS. I think it is something like 50,000,000 yards in this, and in the cut proper I think it is 117,000,000.

Senator GORMAN. What are you comparing it with now, the sea-level project?

Mr. STEVENS. The sea-level project; yes, sir.

Senator HOPKINS. Do you mean cubic yards?

Mr. STEVENS. Yes, sir; I may be wrong in these figures; they are given exactly in the report.

Senator HOPKINS. Yes.

Mr. STEVENS. With the sea-level plan and the Culebra cut—assuming that the cut commences here and ends here—it will go down to about this line here to get 40 feet of water; down to this line here, right there.

Senator SIMMONS. What is the difference between the cut of the sea-level and this lake plan?

Mr. STEVENS. In yards?

Senator SIMMONS. In depth.

Mr. STEVENS. In one case the bottom of your canal is 45 feet above mean sea level, and in the other case it is 40 feet below; there is a difference of about 95 feet.

Senator MORGAN. Mr. Stevens, I want to ask you a question if you please, sir. The sea-level plan contemplates or includes a high dam at Gamboa?

Mr. STEVENS. Yes, sir.

Senator MORGAN. With regulation works in it to draw down any flood waters that might be in the lake above?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Are those flood waters on either plan carried into the canal or through the canal?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Or above it?

Mr. STEVENS. No, sir; I understand they are brought into the canal gradually.

Senator MORGAN. So that all water drawn off in the way of regulation from the lake above would have to pass into the canal?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Would that not be a somewhat risky proceeding in regard to preserving the integrity of the canal itself?

Mr. STEVENS. Of course all of those regulating works must be built of heavy masonry. There is no danger of washing or scouring, no possibility of it; and I should imagine that the water would have to be discharged by separate months, so that at no one point would there be enough water brought in with enough velocity to make currents in the canal sufficient to affect the navigation of ships.

Senator KITTREDGE. What sort of a foundation is there to be for the dam at Gamboa, according to the report of the majority?

Mr. STEVENS. There is rock about 50 feet below the surface of the ground.

Senator KITTREDGE. Is there any difficulty about securing that sort of a foundation?

Mr. STEVENS. Oh, no; oh, no. You understand, Senator, that there are different propositions which the report does not touch on; there have been other ways suggested of taking care of this flood water. The Senator spoke the other day about the work the engineers have been doing. They had projects for digging long tunnels through the mountains back here to conduct the water over to the Caribbean Sea. One survey, I think, was made before my time to take it to the Pacific.

Senator HOPKINS. Restate that, please; I did not catch it.

Mr. STEVENS. I say that other projects, which neither committee reports favorably on, contemplated building this very high dam at Gamboa and flooding this water back; and then, instead of letting the water come out into the canal here, the plan was to put long tunnels through the mountains to carry this water off to the Caribbean Sea and to the Pacific Ocean.

Senator HOPKINS. Yes.

Mr. STEVENS. And in one case, for which I made a partial survey last summer, what is called the Dique cut ("Dique" is the name of the river), the plan was to reverse the flow of the river by digging a tunnel through the mountains and bringing it down into the Caribbean Sea—involving, as I recollect, about a 20-mile cut, some twelve of fifteen million yards.

Senator GORMAN. That was Wallace's project, was it not?

Mr. STEVENS. I do not know who originated that. I have never completed that survey.

Senator KITTREDGE. The French suggested it; the original plan was worked upon by Mr. Wallace and his engineers in connection with a whole lot of other plans.

Mr. STEVENS. But it would seem that the majority of the consulting board did not favor it. They favored having the regulating works directly at the dam.

Senator HOPKINS. And the minority plan provides against that by creating the lake there, and throwing the dead water back here to stop the force of the river?

Mr. STEVENS. Yes, sir; and of course that would apply to all influent streams.

Senator SIMMONS. What would be the effect of creating that immense lake there upon the health of people on the Isthmus?

Mr. STEVENS. From my point of view, I do not think it would affect it, Senator.

Senator SIMMONS. Either beneficially or injuriously?

Mr. STEVENS. I do not think so. I will tell you why. Of course being from the North, as we all are here, and looking at the Isthmus as it exists, I can not see for the life of me where there are ever going to be any centers of population in the interior of the Isthmus of Panama—not of white people. There are certainly no white people going there to farm. In other words, the population in the interior after the canal is built is going to be as it is now, possibly for years to come. Of course "forever" is a long time; but as far as the human mind can predict, the population there is going to consist of natives, who are practically immune. Now, I can not see what great prejudice a fresh-water lake there is going to be. I will admit that if you create fresh-water lakes near the centers of population, particularly white population, there is a question of that kind.

Senator KITTREDGE. A serious one?

Mr. STEVENS. It is generally admitted by all scientists, by our own surgeons, and our own physicians—and I expressed my opinion of their abilities very freely the other day; I think they are first class—that yellow fever and malaria are carried by mosquitoes. Mosquitoes breed in fresh water. Therefore, if you create an artificial lake near the big centers of white population there is that danger of breeding mosquitoes. On the other hand, I understand—if my understanding is right—that these mosquitoes are not bred in deep bodies of fresh water. They breed in marshes, shallow places. I have known them to breed in a wet sponge in my bath room.

Senator SIMMONS. Do they not require some protection of some sort—grasses, or something like that?

Mr. STEVENS. As a rule; yes, sir—dark, moist spots.

Senator KITTREDGE. What would be the effect of these lakes up the Chagres River and along the route of the canal, in regard to the creation of marshes?

Mr. STEVENS. I do not think it would have any effect along the immediate route of the canal, the track of sailing vessels, because they do not breed there.

Senator KITTREDGE. Do they breed at the outskirts of these lakes?

Mr. STEVENS. I think undoubtedly they would. Now, the men who worked for the Missouri River Commission told me that along south from Memphis, and north on the Arkansas River, mosquitoes may be the plague of their lives when they are tied up to the banks, where the water is shallow; but once that they pull their dredges or their boats out into the middle of the river they get no more mosquitoes.

And I think it is pretty well ascertained that the radius of a mosquito's flight is very limited. Unless there is a very heavy wind that carries him away, I do not think that a mosquito ever gets, I should say, 100 yards or 200 yards from the place of his birth. I know that scientific men are making experiments along those lines, and as far as I have been able to read up to this time that is their conclusion.

Senator DRYDEN. You think, then, there would be no danger to people passing along the canal?

Mr. STEVENS. Oh, I do not think there would be the slightest. I do not think that at all.

Senator KITTREDGE. What is the character of the foundation of the dam recommended at Miraflores under the lock plan?

Mr. STEVENS. That is rock, very near the surface. In fact, the railway will have to be moved there for any kind of a canal that is built. There is rock in the vicinity of the locks, within two or three hundred feet. There is a rock cutting right there; the rock is at the surface, or very close to it.

Senator KITTREDGE. And at that point the majority report recommends the construction of a tidal lock?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. And the minority report recommends the construction of a lock for the canal, elevating it 30 feet?

Mr. STEVENS. About 30 feet, as I recollect. In other words, they divide the 85 feet between two locks at Sosa and one at Miraflores.

Senator KITTREDGE. What sort of foundation can be secured for the dams in the vicinity of La Boca and Ancon, and from that point over to the railroad?

Mr. STEVENS. The deepest boring we got there along the site of the proposed dam (and we made a lot of them) was 65 feet to solid rock, and covering that rock is clay. There is no question whatever about the character of the foundation—that is, as to imperviousness.

Senator MORGAN. Now, I would like to have Mr. Stevens take up the sea-level plan—the majority report.

Senator GORMAN. One moment, Senator, before you go to that. Mr. Stevens, tell me what provision is made for the disposal of the silt and the débris that washes down into the canal from the Chagres River where it enters the canal?

Mr. STEVENS. The Chagres River at and above Gamboa carries very little silt. It is a mountain stream, and even in floods—we had quite a flood, or two of them, before I left there—the water as it came down to the railway through Gamboa was clear. Below Gamboa, where we get into the alluvial valley, it gets muddy.

Senator GORMAN. Yes; so that you do not apprehend that it will require constant dredging in the prism of the canal at that point?

Mr. STEVENS. I should say no; I should say no.

Senator GORMAN. In that plan what arrangement have they for spillways for the prism of the canal in case there is too great a volume of water in that lake? Is the location such that you can relieve the canal by the ordinary spillway?

Mr. STEVENS. Yes, sir; you can, in the Gatun dam.

Senator GORMAN. Clear through in the lake level?

Mr. STEVENS. It is intended to regulate that entirely by sluiceways in the Gatun dam.

Senator GORMAN. Not along on the line of the canal?

Mr. STEVENS. No, sir.

Senator GORMAN. Well, that is an entirely different plan from any other canal.

Senator MORGAN. Now, I think, Mr. Chairman, that we had better permit Mr. Stevens to take up the majority report and follow the heads into which it is distributed, and examine the report all the way through, making such criticisms as he has to make upon it, and then

afterwards have him take the minority report and give his criticisms upon that.

Senator KITTREDGE. May I ask one question before that point is reached, Senator Morgan. I think the suggestion is a first-rate one.

Senator MORGAN. Yes, sir.

Senator KITTREDGE. Does the minority of the Board of Consulting Engineers treat upon the question of changing this canal from locks to sea level at a later day? I have not yet had an opportunity to read it.

Mr. STEVENS. The Board as a whole, as I read it, without any division, are strongly of the opinion that that is not practicable; that if a sea-level canal is ever to be contemplated, the time to build it is at the start.

Senator GORMAN. You mean by that that it is too expensive, do you not, Mr. Stevens?

Senator MORGAN. Yes; they concur in that.

Mr. STEVENS. I have here an excerpt or transcript that I made of some of their proceedings some time ago, which I believe is embodied in the reports—a report in which they all agree.

Senator KITTREDGE. Is that embodied in the minority report and in the majority report as well?

Mr. STEVENS. I think it is; yes, sir.

Senator MORGAN. Both the majority and the minority signed it.

Mr. STEVENS. It shows, according to their figures, that it will cost \$246,270,000.

Senator KITTREDGE. To make the change?

Mr. STEVENS. To make the change; yes, sir.

Senator KITTREDGE. As I recollect the reading of the majority report, the 85-foot elevation was not treated of. Is that right? Their figures were upon the basis of a 60-foot elevation, as I recollect.

Mr. STEVENS. This extract which I have here—it has been some time since I have seen it—says that an estimate of the quantities and costs for transforming a lock canal with a summit elevation of 85 feet to a sea-level canal amount to \$246,000,000. They have not detailed it. It is possible that in the report there is a comparison of the cost of transforming a lower lock canal. I do not remember whether there is or not. You have the majority report there.

Senator MORGAN. Now if we can take up a methodical examination of these reports, when we come across one of these questions we will have the figures right before us.

The CHAIRMAN. Senator, as we have started in with the minority report, perhaps we had better finish that and then take up the other. We have started in with Mr. Stevens, on the minority report; so perhaps he had better go along with that and finish it.

Mr. STEVENS. There was one question, if you will allow me—I assume you want all the light there is—

Senator HOPKINS. Yes.

Senator MORGAN. We do.

Mr. STEVENS. I do, myself. I am seeking for light, and any opinion I have so far is only made up from impressions and the data that has gotten in my brain so far. You spoke about taking care of the flood waters by means of the regulating works at the Gatun dam. That is the plan of the minority; but I am not clear as to whether or

not that is the place, in case a dam of that size is built, where the regulation could be effected, up here on the Trinidad River, which comes in here from the west. Here is the canal.

Senator GORMAN. How far is that from the dam—about what distance?

Mr. STEVENS. The Trinidad River comes in about four miles above the dam. Now, going up that stream, which has very little rise—I have been up there several times with a small launch—going up there about five or six miles farther there is a depression in the hills between there and the Caribbean Sea. I sent some men up there to take the elevation and make an examination of the country, and it was made very lately, but I know this: That the top of that pass is only 27 feet above the top of the dam here. That is through natural ground; and, I think, although I have not drilled it, that it is rock. Now, my own opinion is, that before I will permit myself to put in these spill works here, I should examine that very closely; and if it is as I expect to find it, I would plan to put my regulating works at the head of that stream. That would be a similar proposition to the old Gigante spillway of the old Commission.

Senator MORGAN. Yes—the same thing. Now, if you were building a dam at Gatun, could you dam the Chagres at Trinidad—is that the name of the river?

Mr. STEVENS. You would not need any dams on the Trinidad at all. This water would back, you know, to within 27 feet of the top of this pass. You would merely make your cut right through there, and put your regulating works there, and keep them away from the dam.

Senator MORGAN. I am speaking about a diversion of the Chagres for the purpose of building a dam at Gatun.

Mr. STEVENS. Yes, sir.

Senator MORGAN. Could that diversion be made through Trinidad?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And that is 4 miles above the dam at Gatun?

Mr. STEVENS. By the river line it would be probably 8 miles. It is some distance up to Trinidad.

Senator MORGAN. Yes, sir. In any event such a diversion at Trinidad would be a relief to the work of the Gatun dam, even if it did not entirely complete the diversion?

Mr. STEVENS. It would be simply a transference of the regulating works needed for controlling the level of the big lake. Instead of putting it through the dam, you put it through the natural ground.

Senator MORGAN. I never heard of that before, but it looks very nice.

Mr. STEVENS. Yes. In making some reconnoissance through there, I think in defining the Zone line, I found there was a pass through there, and I had it examined with that in view.

Senator GORMAN. What about the other end, as to the Chagres River? You bring the water into the canal about the center of it. What about the spillway at the other end?

Mr. STEVENS. They do not propose to make any spillway there at all. The water all comes through from the north.

Senator SIMMONS. Mr. Stevens, I understood you to say that that lake would flood about 118 square miles of territory. That would involve, of course, flooding a large amount of territory outside of the Canal Zone?

Mr. STEVENS. Yes, sir.

Senator SIMMONS. You do not know how much?

Mr. STEVENS. The minority report makes an estimate of that.

Senator SIMMONS. All of that would have to be paid for by the Government?

Mr. STEVENS. Yes, sir; as I say, the minority report contains an estimate of that.

Senator SIMMONS. I have not seen the report at all.

Mr. STEVENS. Yes, sir; and what I am about to state is altogether a coincidence, because, you understand, I knew nothing about either of these reports. In a general way I knew that the newspapers said that there was a division in the board; but in my spare time from my other duties I gave considerable time and interest to this matter, and that idea was one of the first that occurred to me—whether the plan of a big dam at Gatun would not flood so much valuable territory, millions and millions of dollars' worth of property, as to be out of the question.

But taking the Zone map, and taking the United States ownership, and including the Panama Railroad ownership, I figured that putting the value of the land as high as I possibly could, stretching my conscience to that extent—mind you, if I were buying there I would not pay any such prices—it would be necessary to acquire not to exceed \$300,000 worth of privately owned tracts; and I find that the minority report have the same figures, although how they arrived at them I do not know.

Senator MORGAN. I would like to remark that the treaty, as I understand it, settles all these questions by fixing the value of all property that is condemned at its value before the improvements were commenced.

Senator HOPKINS. Yes; the treaty protects us in that respect.

Senator MORGAN. Yes. That, of course, is a mere bagatelle; and I would like to make this statement: That if there is any way in the world to flood out, decently, those little villages along on the Chagres River, I would like very much to do it. I do not want any people in there except the ones that are working on this canal.

Senator HOPKINS. Well, Senator Simmons, as I understand what the treaty provides, it is this: Taking the amount of territory outside of the Zone that will be flooded, in determining the value of that territory between our Government and the Panama Government, the value of that land before this canal is touched is the value that will be fixed upon.

Senator SIMMONS. That part of it which is covered with water will have no value, Senator.

Senator HOPKINS. No; but we take it, and we pay for it—

Senator SIMMONS. You buy it absolutely.

Senator HOPKINS (continuing). We pay for it on a valuation prior to any improvements at all.

Senator SIMMONS. Then you have to consider the question of what is the effect of that flooding upon the abutting land.

Senator HOPKINS. Oh, yes.

Senator SIMMONS. That will be another question.

Senator MORGAN. I venture to suggest that before this committee get very far into this subject they will be very glad of any opportunity to remove the people from those villages along the Chagres River.

The CHAIRMAN. Senator, I think the lake itself will remove the people. Is not that correct, Mr. Stevens?

Mr. STEVENS. Undoubtedly.

The CHAIRMAN. They will all have to go away. They have no rights there, as I understand it.

Senator HOPKINS. However, as Mr. Stevens has said, we have the estimate both of himself and of the minority that it will be about \$300,000, which is a mere bagatelle when you consider the other expenditures.

The CHAIRMAN. If you saw the conditions down there you would think Mr. Stevens's estimate was large enough.

Mr. STEVENS. The greater part of the land is a marsh. People have been there that we know of—our records go back there four hundred years; and I do not believe that to-day there is on the Canal Zone, outside of the little towns and the railroad right of way, the equivalent of two square miles of cleared land.

Senator SIMMONS. Mr. Stevens, I want to ask you this question: Beyond the flood line of this lake is there any settlement? Would there be any settlements out there?

Mr. STEVENS. There are none now, unless you go up the streams. I imagine there are some there. I never have been away up very many of them.

Senator GORMAN. Mr. Stevens, I see that the minority report, on page 29, states that the 118 square miles of lake surface, on their lock plan, will require the acquisition of 20,480 acres of private ownership, and that the average cost of the land will be \$7.70 an acre.

Mr. STEVENS. Yes.

Senator GORMAN. That is rather insignificant. You would be compelled, according to this statement, to purchase land in either case—with either a lock or a sea-level canal.

Mr. STEVENS. At the bottom of that page you will notice, Senator, that they say:

An approximate estimate may, therefore, be based on the price per acre paid by the Canal Company for the whole area it acquired, and such an estimate would be 38,400 acres at \$7.70 per acre, making the total cost \$295,680, or, in round numbers, \$300,000. While the actual cost is likely to exceed this somewhat, no better data for an estimate exists. It would be neither good judgment of values nor to the interests of the United States to submit an extravagant figure.

Of course an estimate of that kind must necessarily be very approximate.

Senator GORMAN. Yes.

Senator MORGAN. Now will the committee take up first the majority or the minority report?

The CHAIRMAN. As Mr. Stevens has been talking about the minority report, would it not be better to finish that?

Senator MORGAN. Had we not better ask Mr. Stevens to take it consecutively, commencing out in the Bay of Limon and going right along, and let him state any difficulties there are of an engineering sort or any possibilities that in his opinion may prevent the canal being built on the plan suggested in the minority report?

The CHAIRMAN. Yes, sir.

Senator MORGAN. Now, Mr. Stevens, please take up that minority report and go through it by heads in your own way.

Mr. STEVENS. The minority report contemplates starting at the 45-foot line (it is $7\frac{1}{2}$ fathoms; I think that is 42 or 45 feet) in the outer harbor, about where my ruler lies, and excavating a channel 500 feet in width.

Senator MORGAN. Is that wide enough?

Mr. STEVENS. With a straight entrance like that, I should say yes—with no cross winds.

Senator MORGAN. Go ahead.

Mr. STEVENS. Then following this line [indicating], passing this point, striking the old canal here, and following this canal through to Gatun and to this point [indicating].

Senator KITTREDGE. You say "striking the canal here?"

Mr. STEVENS. I mean the present canal.

Senator KITTREDGE. You mean at the mouth of the Mindi River?

Mr. STEVENS. Above the mouth of the Mindi River; about here, as I recollect it; about here they swing off.

Senator KITTREDGE. How far is that from the mouth of the Mindi?

Mr. STEVENS. The mouth of the Mindi is right there; it is, say, half a mile at the nearest point of the curve 500 feet in width from this point here to Gatun. As I recollect now, there is some doubt in their minds whether it will be necessary, but for the purpose of comparison with a sea-level canal they put in \$5,000,000 for breakwaters on each side of this channel—parallel with it—these breakwaters to be built in case the experience in the next four or five or six years shows them to be necessary. Of course they could be built at any time. It is a question whether a channel excavated along the line that their report contemplates could be kept open without constantly dredging at high expense—that is, keeping dredges at work there all the time—but the opinion of the entire board is that with this jetty or breakwater it could be done.

Senator SIMMONS. That would be excavation through solids from where you leave the Bay of Limon, would it not?

Mr. STEVENS. From this point [indicating]?

Senator SIMMONS. Yes.

Mr. STEVENS. Oh, yes; the excavation is through swamps until you get up—away up to San Pablo.

Senator SIMMONS. I am talking about the 500-foot-wide excavation. I say that would be through solids, would it not, from the Bay of Limon to that point which you mentioned there?

Mr. STEVENS. Here [indicating]?

Senator SIMMONS. Yes.

Mr. STEVENS. Why, it would be earth, clay, sand, etc.; the alluvial matter that has been brought down by the river here for ages. Now, at Gatun—

Senator MORGAN. Before you get there, if you please, I want to ask you just one question. A ship entering the canal would keep that breakwater on its starboard side?

Mr. STEVENS. Yes, sir.

Senator MORGAN. The whole length, coming into the coast?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Going out, of course, it would be on the larboard side?

Mr. STEVENS. On the port side—yes, sir. Therefore they will have a 500-foot channel up to Gatun. At this point is the location of the

proposed high dam. This dam is to be 135 feet high, or 50 feet above the level of the water in the proposed lake. That 50 feet, as I understand, is simply to give more weight and solidity to the dam. It is a grave question in my mind whether all of that is needed or not. However, that is merely an opinion. This dam is to be, on the base, about 2,700 feet in width, about one-half mile up and down the stream.

Senator MORGAN. That is, a cross section of the dam?

Mr. STEVENS. Yes, sir.

Senator MORGAN. At the level of the water?

Mr. STEVENS. No; at the bottom.

Senator MORGAN. I mean at the bottom.

Mr. STEVENS. At the level of the water my recollection is that it is 374 feet. You see, I have no plans yet; I only have their general description in my head.

Senator ANKENY. What is the foundation of the dam?

Mr. STEVENS. Clay—an impervious clay.

Senator ANKENY. That is sufficient, is it?

Mr. STEVENS. Yes, sir; in my opinion it is. That dam contains, as I recollect, about 2,100,000,000 yards of material; and it is proposed to build it out of earth.

Senator KITTREDGE. Is the foundation to be of earth? You are to go below the surface of the water, of course, for your foundation?

Mr. STEVENS. We will simply take off the detritus, the vegetable accumulation, and go down to where it is absolutely firm—just as if you were going to build a wall down here in the woods; you would dig off the muck and the loose stuff until you got down to absolutely firm soil.

Senator KITTREDGE. And then you would pile in the dirt?

Mr. STEVENS. Then we would commence to put in the dirt; yes, sir.

Senator KITTREDGE. And that is all there is to be done in reference to the foundation?

Mr. STEVENS. That is all there is to be done in reference to the foundation. This dam, as I say, will be half a mile thick at the base, and 375 feet thick at the water-level. The construction that is proposed for that is not to pile that dirt in there largely from railroad trains, but to take it from the mass that is excavated here by dredges, bring it up to that point, and pump it with hydraulic pumps from the barges, or drop it into a basin and pump it from there into the dam. There are two reasons for that, both very good ones. One is that this material must be disposed of in any case; if not put into some works like this, it must be taken out to deep sea and dropped.

Another is that a bank can be made very much more solid in every way, with practically no shrinkage, by mixing it with water as you are putting it in. In other words, the material puddles, and the clay with very little mixture of sand, which obtains through here, would be an ideal quality of material for that construction. At the same time, I have suggested to our people that in case such construction is carried out, a certain part of the dam can just as well be made of material from the Culebra cut, brought down in trains and run on and allowed to mix with this material, so that it will all become puddling.

I know from my own experience that a bank built largely out of material cast up with shovels, put in with wheelbarrows, or dropped

from railroad trains, will settle for years to come; but I know, on the other hand, that material of this nature, put in with pumps, where we will say, that the material as it goes into the bank is composed of about five or six parts of water to one of earth, becomes the hardest and solidest bank it is possible for man to build; and that as a rule banks built of that material in that manner are just as solid as any mountain that the Lord made of the same material. Do you see what I mean?

Senator GORMAN. That puddling of ordinary material I know applies to clay, but does it apply to the material dredged out down there?

Mr. STEVENS. Yes, sir; the material that is dredged is largely clay.

Senator MORGAN. The mountains were made in the same way by deposits from water?

Senator SIMMONS. But you suggest a mixture of some clay from the Culebra cut with that?

Mr. STEVENS. That is simply on the score of economy. We will have a large amount of stuff to deposit in any case that will have to be hauled somewhere in this vicinity.

Senator SIMMONS. Not because it is necessary?

Mr. STEVENS. No, sir; not because it is necessary, but simply from the cost of construction.

So much for the dam. Are there any more questions about that?

Senator MORGAN. Have you perfect confidence, Mr. Stevens, as an engineer, in the practicability of that dam, both in respect of the work of putting it in and of its steadfastness against all possible pressure from the Chagres waters in the future?

Mr. STEVENS. As far as the question of pressure is concerned, I do not think that admits of any discussion. Taking the depth of water and the weight that will be imposed against it at the bottom, it is something like one-sixtieth or one-seventieth of the weight of the mass; and it would be, in my opinion, like one of us going out here and undertaking to push this wing of the Capitol away from the main body of the building.

Senator MORGAN. If you had your choice between putting in at that place such a dam as is mentioned in the minority report here in great detail, and a dam of cut stone with rock foundations, if such a rock foundation could be had, which would you prefer?

Mr. STEVENS. I would prefer the earthen one—this one.

Senator HOPKINS. Give your reasons for that.

Mr. STEVENS. In the first place, I think the earthen dam, particularly if built of the dimensions they propose, could not be compared in strength with any other, because it is absolutely so strong that no power could ever move it. It is like killing a duck; when you kill him he is dead; there is no use in trying to kill him any "deader." If he is dead he is dead.

Senator DRYDEN. Mr. Stevens, you say this dam is about half a mile in length across the cut?

Mr. STEVENS. I mean thick, against the water at the base.

Senator DRYDEN. How long would it be?

Mr. STEVENS. The dam is about 7,000 feet. I will call it, across the valley.

Senator DRYDEN. A mile and a half.

Mr. STEVENS. Yes, sir.

Senator SIMMONS. And 375 feet wide at the water?

Mr. STEVENS. That is my recollection, at the water level; yes.

Senator MORGAN. Let me ask you whether the length of that dam would not so distribute what we call the pressure of the water as to make the dam of still greater resistance to the whole mass of the lake than if it was a short dam?

Mr. STEVENS. No, sir. Water pressure varies in proportion to its depth. In other words, an inch of water at a given height will give the same pressure as if it was a mile long. Taking the weight of a column of water, to get the pressure at the bottom, you can multiply it by four-tenths. In other words, in the case of a column of water 100 feet high, you get a pressure of 43 pounds a square inch at the bottom.

Senator MORGAN. I think you have expressed a doubt as to the plan, or as to the practicability, or as to the usefulness of the spillway at the western end of that dam. Have you any suggestions to make in regard to that spillway?

Mr. STEVENS. There is one point that may not be quite clear here; I think I can explain it without pointing it out on the map, for you would not see it if I did. About midway of the valley, between two or three channels of the Chagres River, and what I call the old French diversion that they undertook to build there, one of the channels, there is high-ground that runs up nearly to the top of the dam; and it is on this natural ground that it is proposed to build the spillway; not through the artificial dam. That was one of the strong points, as I understand—or as I infer, rather; I did not understand anything about it; I do not know what controlled them—in favor of building the dam at that point. There is a detached mountain which forms a part of the dam. The top is, generally speaking, about the height of the dam as proposed, and at that point, through this natural ground, the minority of the board propose to build their regulating works.

Senator MORGAN. You propose, then, to dig this spillway right through that mountain?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Leaving out the spurs on either side?

Mr. STEVENS. Yes, sir.

Senator SIMMONS. It is to be a part of the dam?

Mr. STEVENS. It is to be a part of the dam.

Senator MORGAN. Do you know anything about the stratification in that hill?

Mr. STEVENS. Oh, yes; it is the same as the balance. It has been bored all over. It is very largely indurated clay.

Senator MORGAN. You have a commodity down there that all the engineers call indurated clay?

Mr. STEVENS. Yes, sir.

Senator MORGAN. What is it?

Mr. STEVENS. I think it is what geologists call tufa.

Senator MORGAN. Ejected from volcanoes?

Mr. STEVENS. The definition of tufa is that it may be made either by the action of heat or by water; but I think that is wrong. My own impression is that that particular material is made by the action of water, and then afterwards hardened by heat, having been subjected to terrific heat.

Senator HOPKINS. Mr. Stevens, I wish you would indicate on the map there just where the dam is and where the spillway is to be.

Senator SIMMONS. Suppose he marks it.

Senator HOPKINS. Yes; then we can see where it is to be.

Senator SIMMONS. I think if we had that dam marked on there it would help us here very much.

Mr. STEVENS. Approximately, across there [indicating by marking]. Here is the little mountain that I speak of.

Senator HOPKINS. That is the mountain you speak of, where the spillway is to be?

Mr. STEVENS. Yes, sir.

Senator HOPKINS. Oh, yes; I see.

Mr. STEVENS. Then the dam goes across, I think, about on that line, across the high ground over here.

Senator KITTREDGE. Is it diagonally across the river?

Mr. STEVENS. Well, it is not a straight line. Yes; it crosses the little channel diagonally.

Senator HOPKINS. At what point of the dam is the spillway to be made?

Mr. STEVENS. About here [indicating].

Senator MORGAN. The extreme western terminus of that dam is in a ridge?

Mr. STEVENS. Yes, sir; over here. Yes; these mountains extend there and back. They form the crest between the waters of the Trinidad, which comes in here, and the ocean.

Senator MORGAN. It is that ridge?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Now, let us get to the other end of that dam. At the other end are the locks?

Mr. STEVENS. The proposed locks are right through here.

Senator MORGAN. Are those locks at the extreme eastern end of the dam?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Or does the dam extend beyond them?

Mr. STEVENS. They are just outside of the eastern end of the dam.

Senator MORGAN. Just outside?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Between them and the hills?

Mr. STEVENS. They are on the hills. The high lock, of course, would be on the hills.

Senator MORGAN. Those locks, if I correctly understand it, are in three flights?

Mr. STEVENS. That is recommended; yes, sir.

Senator KITTREDGE. Where, with reference to the railway station at Gatun, does the dam cross the valley?

Mr. STEVENS. Of course it covers the whole station.

Senator KITTREDGE. I understand; but the southern side of it?

Mr. STEVENS. The center of the mass of the dam would probably be a little south of the present railway station.

Senator KITTREDGE. Do you know where the home of the mayor of Colon is?

Mr. STEVENS. Up on top of the hill?

Senator KITTREDGE. Yes, sir.

Mr. STEVENS. Yes; I do not recall his name—Sylvia is it not?

Senator KITTREDGE. I do not recall that.

Mr. STEVENS. I do not recall his name now.

Senator KITTREDGE. Where, with reference to his home, is the eastern extremity of the dam?

Mr. STEVENS. Right there [indicating].

Senator KITTREDGE. And a lock just beyond?

Mr. STEVENS. The locks would be right there at his house—right on top of that hill.

Senator KITTREDGE. At what angle does the dam cross the river?

Mr. STEVENS. That is very hard to say. Of course, it crosses the valley at right angles, but the little channel—

Senator KITTREDGE. That is what I mean—the river.

Mr. STEVENS. I could not say as to that. I should say probably not to exceed 20 or 30 degrees out of a right angle. You see, the little channel cuts no particular figure in high water. Then it is all channel.

Senator DRYDEN. What is the width of those locks?

Mr. STEVENS. The width that is proposed by the committee is 95 feet.

Senator KITTREDGE. And the length?

Mr. STEVENS. Nine hundred feet.

Senator MORGAN. Now, you have three flights of locks, have you?

Mr. STEVENS. Three flights; yes, sir.

Senator MORGAN. One above the other?

Mr. STEVENS. Yes, sir.

Senator MORGAN. They are twin locks?

Mr. STEVENS. Yes, sir.

Senator MORGAN. That would make six chambers, or six locks?

Mr. STEVENS. Yes, sir.

Senator MORGAN. What is the elevation at each of those, if you remember?

Mr. STEVENS. I do not remember; I have not seen the detailed plans, you know.

Senator MORGAN. At any rate, the whole is 85 feet?

Mr. STEVENS. The whole elevation is 85 feet.

Senator MORGAN. Divided into three locks?

Mr. STEVENS. Just how they are divided I do not know.

Senator MORGAN. Is the ground where those locks are to be located firm ground, good ground?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Not marshy in any sense?

Mr. STEVENS. No, sir.

Senator MORGAN. Is it a hill?

Mr. STEVENS. Yes, sir.

Senator MORGAN. That raises the water to an elevation of 85 feet?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And that elevation stretches clear across these cuttings here to Miraflores?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Now, progressing from those locks, following the line of the canal, I understand that the minority report proposes to take all stumps and trees, and everything of that sort that may be found, out of the bed of the lake created by the dam?

Mr. STEVENS. They propose, as I understand their report, to provide, from the Gatun dam up to the 23.6 miles—this, unfortunately, is not given in miles; it is given in kilometers; about three-quarters of a mile—up in this vicinity here—up near Tavaernilla—they propose to have a channel not less than 1,000 feet wide, clear.

Senator MORGAN. Cleared?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Cleared of everything?

Mr. STEVENS. Of everything.

Senator KITTREDGE. How deep?

Mr. STEVENS. And the water at that point would run from, say, 75 to 80 feet at the back up to possibly 50 feet throughout that distance.

Senator MORGAN. And that carries it beyond Bohio?

Mr. STEVENS. Oh, yes, sir; yes, sir.

Senator DRYDEN. Can you tell how long it would delay a boat of the largest character that would be likely to go through there to be lifted up and go through one of these locks?

Mr. STEVENS. To get through the three locks?

Senator DRYDEN. Yes, sir.

Mr. STEVENS. They ought to go through in from forty-five to fifty-five minutes.

Senator DRYDEN. Have you any idea how much expense that operation would be to the boat?

Mr. STEVENS. To the boat itself?

Senator DRYDEN. Yes; lifting it up and putting it through?

Mr. STEVENS. No, sir; I have not, because I have never gone into those details of the estimates. The minority report gives a careful estimate of the cost of operation, based on so many lockages in a year. No; I could not give you that.

Senator MORGAN. Between the lock and this point here which you have mentioned in that thousand-foot width of clearing, have you any other suggestion to make, or any alteration or improvement, except the one which you have suggested in regard to the Trinidad River?

Mr. STEVENS. No; I am not aware of any. I do not want to claim the credit, if there is any credit attached to it, of this suggestion here. It may have been known by other parties.

Senator MORGAN. I expect it was.

Mr. STEVENS. Possibly their report touches on it.

Senator MORGAN. None of us know much that has not been known before, anyhow.

Mr. STEVENS. That is right. I simply tendered that for your information.

Senator HOPKINS. Is that thousand feet in width of a uniform depth of 50 feet?

Mr. STEVENS. It is nowhere less than 50 feet, according to my recollection. Gradually, as the valley rises and the water keeps level, of course it gets a little shallower.

Senator HOPKINS. Yes.

Mr. STEVENS. But my impression is that up to that distance there is never less than 50 feet of water. I do not think there can be.

Senator SIMMONS. Where is the point you mentioned?

Mr. STEVENS. I said near Tavernilla; but it is just as liable to be four or five miles from there. I do not know, Senator; I will say an indefinite point up the valley.

Senator MORGAN. Between the points I have been referring to now you do not suggest any work in addition to what is mentioned by the minority report, except the probability of useful work being put in there in the Trinidad River?

Mr. STEVENS. I do not recall any now, Senator.

Senator MORGAN. Nothing at all?

Mr. STEVENS. No, sir.

Senator MORGAN. Then that enables us to go up to this point [indicating]. Passing now from this point up to Gamboa, what have you to say?

Mr. STEVENS. Let me refer to this plan. I think there are miles on this, instead of kilometers, so that I can clear up that point. That channel is to be not less than one thousand wide—a thousand feet or more; that is, in this level part here it would be 2 miles wide, but a thousand is the minimum. You see, that runs up to 23.66 miles. Now, you see, I was wrong. That is about a mile and a half above Tavernilla. It is very nearly to San Pablo, within about half a mile of San Pablo, that that minimum channel of a thousand feet would extend.

Senator MORGAN. After you have constructed this dam and have your lake established there and the water all over this country there would be several villages that would be submerged, would there not?

Mr. STEVENS. Yes, sir.

Senator MORGAN. That we would have to pay for?

Mr. STEVENS. Well, I do not know what arrangement would have to be made with them. They would have to get out of there, of course.

Senator MORGAN. Yes; they would have to get out.

Mr. STEVENS. They are all there on leases from the Panama Railroad, so far as I know. There are no towns or villages away from the railroad; and they are all on the Panama Railroad line land under leases subject to thirty days' notice.

Senator MORGAN. So that we have taken over the property with the privilege of dispossessing the tenants on thirty days' notice?

Mr. STEVENS. Those old Panama Railroad leases are all drawn on that basis.

Senator MORGAN. Very good.

Mr. STEVENS. Without any prejudice to the railroad company.

Senator MORGAN. Yes. What is the name of the point to which you said that extended?

Mr. STEVENS. San Pablo.

Senator MORGAN. Now we will take the canal from San Pablo up to Gamboa.

Mr. STEVENS. From this point—say from mile 24 to mile 27½—the channel is to be from 800 to 1,000 feet wide.

Senator MORGAN. That channel is to be cleared of all wood and stumps and trees and everything of that sort?

Mr. STEVENS. That is my understanding of it; yes, sir.

Senator MORGAN. That is the plan of the minority?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. There is a little excavation.

Senator MORGAN. And there would be some excavation or trimming of the spurs in order to keep the line of navigation as straight as possible?

Mr. STEVENS. There would be a little when you got up to that point; yes, sir.

Senator HOPKINS. At what point would there be the trimming you speak of?

Mr. STEVENS. I can not tell you just to what point it would extend without a proper profile, which I have not here, but somewhere in that vicinity.

Senator MORGAN. Is that a job of any special importance—the trimming out of these spurs and straightening the line and cleaning up the timber out of this place?

Mr. STEVENS. Why, only to get the longest straight channel and the longest deep channel that you can; that is all.

Senator MORGAN. It is not a very costly proceeding?

Mr. STEVENS. I do not understand that it is; no, sir.

Senator MORGAN. Nothing like digging the canal?

Mr. STEVENS. Oh, no; no, sir.

Senator MORGAN. Now we get to Gamboa. Have you any suggestions to make of improvements or changes in the plan of the minority between Gamboa and this other point?

Mr. STEVENS. You mean from Gamboa to Gatun?

Senator MORGAN. From Gamboa down to this point you mention—San Pablo. Have you any suggestions to make of any changes or improvements or betterments in that area between San Pablo and Gamboa?

Mr. STEVENS. The only possible change that I see that could be made would be one of decided change in the alignment of the canal, and I do not believe that is practicable. I do not believe any of those changes are practicable.

Senator MORGAN. You think they have the best alignment that is practicable?

Mr. STEVENS. I think they have; yes, sir. It seems to me that the old French work—the technical work of alignment of the canal—was very excellently carried out.

Senator MORGAN. And it has been followed by all of the engineers who have inspected the work since when they have examined it?

Mr. STEVENS. Practically.

Senator MORGAN. Yes, sir; very good. So the alignment would stand, and there are no other matters there. Of course, some villages would be swept out of existence along that area—Matachin and several others?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And they are under the same plan of leases from the railway?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Terminable at thirty days' notice?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Now, at Gamboa, have you any suggestion to make that you think would improve the plan of the minority of the committee?

Mr. STEVENS. At Gamboa?

Senator MORGAN. Yes.

Mr. STEVENS. The plans of the minority report at Gamboa do not contemplate anything there excepting merely the prism of the canal. The point that you spoke of some time ago, of making a large basin there, may or may not have merit in it; but my private opinion is that it would never be needed, and I should hesitate to recommend it. But I can not recall any other suggestion that I would make.

Senator MORGAN. Is there any necessity of paving the way over which the waters would flow into the canal from the dam—I mean from up the stream?

Mr. STEVENS. Do you refer to the Chagres?

Senator MORGAN. Yes. You just take the natural bottom as it is, do you?

Mr. STEVENS. We take the natural bottom as it is, seven, eight, or nine miles away from the canal. That is where the water strikes it.

Senator MORGAN. And you put in no works at all?

Mr. STEVENS. I would not put in any works at all.

Senator MORGAN. In the Chagres River, above Gamboa?

Mr. STEVENS. No, sir.

Senator MORGAN. None at all. And you feel confident that the 35-foot or 40-foot head of water in the canal, which is brought into a lake, would furnish sufficient resistance to the flow of the Chagres River to dam it back, even above Alhajuela, and make a lake there also?

Mr. STEVENS. Yes, sir.

Senator MORGAN. In other words, that the dam at Gatun would affect the Chagres River even as far as a mile or two above Alhajuela, and convert that also into a portion of this lake?

Mr. STEVENS. My recollection is that it does not go above Alhajuela; it goes in the vicinity of Alhajuela; I do not remember just where.

Senator MORGAN. Well, wherever it may be.

Mr. STEVENS. But I think it would go far enough and make a body of dead water of such size and distance from the canal that it never would make a rush of water in the canal that would affect navigation.

Senator MORGAN. That body of water would be made dead water by the fact that there was a dam at Gatun?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And by no other fact?

Mr. STEVENS. By no other fact.

Senator MORGAN. Very good; and you would be satisfied with that. Now, passing on from Gamboa to the mouth of the Obispo, how far is that? It is right at it, is it not?

Mr. STEVENS. It is very nearly at it; yes, sir—half or three-quarters of a mile.

Senator MORGAN. So that the Obispo River would also be under the influence of this dam at Gatun, and its outpour would become dead water?

Mr. STEVENS. Pardon me for digressing, but the Obispo and its tributaries, such as the Camacho on the west side—the effect of creating this lake would be to drive the water up those valleys a long distance; I do not know how far. But in case of the largest tributary on the side, which is—let me see if I can get the name of it; I can not recollect those names very well—the Mandigo; it would drive the water up the Mandigo (where, as I remember, the largest flood comes

from) something like three or four miles. It is a small river, anyway.

Senator MORGAN. And then the canal would follow practically, I suppose, the valley, or what we call the valley, of the Obispo, until it struck the ridge at Emperador, or in that vicinity?

Mr. STEVENS. Yes, sir.

Senator MORGAN. There your digging would commence?

Mr. STEVENS. The digging would commence at about at Bas Obispo, about 1 mile from Matachin.

Senator MORGAN. What is the width of the channel now from Bas Obispo up to Emperador. That is the first height, is it not?

Mr. STEVENS. Obispo is between mile 30 and mile 31. At mile 31 they narrow to 300 feet.

Senator HOPKINS. They narrow the channel of the——

Senator MORGAN. Of the canal. What is the length of that section of 300 feet?

Mr. STEVENS. About a mile and a half.

Senator MORGAN. It is about a mile and a half long?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And then you strike the ridge at Emperador?

Mr. STEVENS. You would strike it between Cascadas and Emperador, a little distance east; it is where the big rise in the mountain commences. Of course, the Emperador, here, would go right on that.

Senator MORGAN. And from that point clear through to Miraflores there would be digging?

Mr. STEVENS. There would be digging; yes, sir; but from that point through the 200-foot width would extend to Paraiso—about 4 miles. Well, it is about, say, 5 miles.

Senator MORGAN. Then you have 5 miles of mountain work to dig through?

Mr. STEVENS. Yes, sir.

Senator MORGAN. With a canal of 85 feet elevation?

Mr. STEVENS. You have more than 5 miles. The 5 miles will be only the 200-foot width. Then there would be a little piece at the end, from Paraiso to Pedro Miguel, and then from east of Emperador down to Bas Obispo, the 300-foot width.

Senator HOPKINS. That 5-mile cutting that you speak of is what has been termed by some the "Culebra" cut, is it not?

Mr. STEVENS. Yes; that is what is known by the general name of "Culebra cut." It starts on this proposition: Here is Hart Obispo, and here is Bas Obispo. "Hart Obispo" means "Hart Bishop," and "Bas Obispo" means "Low Bishop." It starts right here, where these contours come in. These crooked lines represent the different elevations. There is really where the cut starts, and then it gets here to Pedro Miguel, where you drop it again at these crooked lines.

Senator HOPKINS. That is a distance of 5 miles, is it?

Mr. STEVENS. That is a distance of about 8 miles.

Senator MORGAN. Is that the 200-foot cut, the 8 miles?

Mr. STEVENS. No, sir; the 200-foot cut would start, we will say, about—let me see: Here is Emperador; here is Las Cascades, about here. From here to here it would be 300 feet; from here through to Paraiso, which is about here [indicating].

Senator KITTREDGE. Paraiso is where you strike the Culebra cut proper?

Mr. STEVENS. No; Paraiso is just on the south side of the summit of the cut. From this point here to this point here, at Paraiso, it would be 200 feet; from there [indicating] it would be 300.

Senator MORGAN. Now we will take that 200-foot section—that is the most interesting part of it, I think; can that be made any wider without very great expense?

Mr. STEVENS. Well, "expense" is a comparative term. It can be made wider, of course, at any time by simply widening it."

Senator MORGAN. You can widen it?

Mr. STEVENS. Of course; you can widen it on any plan of canal.

Senator MORGAN. So that if it is found to be too narrow we can go to work and cut it out?

Mr. STEVENS. Oh, yes.

Senator MORGAN. We can change that 200-foot width and make it 300 feet, if we want to?

Mr. STEVENS. Yes.

Senator MORGAN. Taking into consideration the fact that there will be great expense attached to it, of course?

Mr. STEVENS. Yes, sir.

Senator MORGAN. In widening it from 200 to 300 feet, you would have to trim off the slope of the mountain above it?

Mr. STEVENS. Altogether.

Senator MORGAN. All the way to the top?

Mr. STEVENS. Yes.

Senator MORGAN. Very good.

Mr. STEVENS. You would have to take off a parallel slice all the way up.

Senator MORGAN. All the way through, if you wanted to widen it; but you can widen it?

Mr. STEVENS. Oh, yes.

Senator GORMAN. What is the width on the bottom in this 200-foot section?

Mr. STEVENS. Two hundred feet.

Senator MORGAN. How long is that 200-foot cut?

Mr. STEVENS. Between 4 and 5 miles.

Senator HOPKINS. You say it is 200 feet wide at the bottom?

Mr. STEVENS. At the bottom.

Senator HOPKINS. What is the width at the top?

Senator KITTREDGE. The top of the water or the top of the cut?

Senator HOPKINS. I mean the top of the cut.

Mr. STEVENS. Oh, the top of the cut?

Senator HOPKINS. Yes.

Mr. STEVENS. I could not tell you; in some places it would be—

Senator DRYDEN. It would vary, I suppose.

Mr. STEVENS. In some places it would be over a quarter of a mile. Neither could I tell you from memory what the slopes are, now, on the water. I think they are 1 to 1.

Senator MORGAN. Putting that 200-foot cut, which is 40 feet deep, is it not—

Mr. STEVENS. Yes, sir.

Senator MORGAN (continuing). At an elevation of 85 feet above the level of the sea, does that elevation refer to the bottom of the canal or the top part of it?

Mr. STEVENS. The 85 feet is the top; the bottom of the canal would be 45 feet.

Senator MORGAN. Yes; that goes through rock.

Mr. STEVENS. Not altogether; it goes through different classes of material. Yes; it goes through rock.

Senator MORGAN. Down to the bottom of the canal?

Mr. STEVENS. Down to the bottom of the canal?

Senator MORGAN. Very good.

Mr. STEVENS. It is of different degrees of hardness, you understand.

Senator MORGAN. I understand; but it would all require blasting or breaking up?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Steam shovels, if I understand you correctly, are capable of handling that material without any special difficulty?

Mr. STEVENS. After it is——

Senator MORGAN. After it is broken up?

Mr. STEVENS. After it is shaken up, broken up; yes, sir.

Senator MORGAN. So that in the hauling out of the material from the cut there would be a saving because it would be condensed rock instead of earth—a saving in the transportation, the handling? If you handle 5 tons of rock or 4 tons or 3 tons with a steam shovel, it seems to me that would be a cheaper way of handling it than if it was earth and you had to dip it up and put it on cars and roll it out.

Mr. STEVENS. Well, no; I do not think that is quite true.

Senator MORGAN. You do not think so?

Mr. STEVENS. You must understand that rock expands, when it is broken up, very much more than earth when it is disturbed. For instance, I imagine——

Senator MORGAN. It occupies a larger area?

Mr. STEVENS. You can only tell exactly after you get through by measuring your dumps and everything of that kind, which will never be done; but I would imagine that the amount of space that you will actually haul in moving a million yards of rock—which means rock in place as God left it, as nature left it——

Senator MORGAN. Would that rock be suitable for the building of the locks at Gatun?

Mr. STEVENS. I do not think so.

Senator MORGAN. You think not?

Mr. STEVENS. If you will let me go on—a million yards of rock in place will about equal a million and a half, and possibly 1,700,000 yards, when you get it out in a dump. It expands, and earth does not expand to any such degree.

Senator MORGAN. Yes. Now, the minority of the engineers, or the commission, as I will call it, seem to think that the revetment which is put in there by the Isthmian Canal Commission (which would be, taking both sides together, about 18 miles long, a stone wall) is not necessary except at one point, where material is found that is likely to slip; but a large portion of this 200-foot cut would not need revetment.

Mr. STEVENS. I see that that is their opinion.

Senator MORGAN. Is that your opinion?

Mr. STEVENS. Senator, I do not think that any living man is competent to express an opinion which would not be subject to revision after he digs the cut; I would not care to.

Senator MORGAN. Do you think the probabilities are in favor of the position of the minority, that a continuous wall of revetment would not be necessary, perhaps, in that cut?

Mr. STEVENS. Oh, I think that is undoubtedly true; to what extent I do not know. In other words, it would not be necessary to revet both sides of the whole length of the cut, because I should hesitate to recommend a 200-foot channel if I thought that in a few years I would have to widen it and take out a wall for the whole length.

Senator MORGAN. Making an allowance for the revetment, if you have to put it in you also have to enlarge your 200-foot width of channel?

Mr. STEVENS. It should be done; yes, sir.

Senator MORGAN. So that the 200 feet should stand between the revetment walls?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Clear space?

Mr. STEVENS. Yes, sir.

Senator MORGAN. In that part of the cut where this 200-foot channel is found would the walls of the canal be perpendicular?

Mr. STEVENS. That is the recommendation of the board, that in those narrow channels they should be made perpendicular and smooth.

Senator MORGAN. Do you concur in that recommendation?

Mr. STEVENS. Yes, sir; I think that is necessary.

Senator MORGAN. You have no objection to make to their position on that point?

Mr. STEVENS. No, sir. Here is a map or a profile or a section which was made from some additional borings which Mr. Wallace made during his connection with the enterprise; and while this does not show all of the borings, as you understand, it gives a general idea of the Culebra cut. At every kilometer (which is about 3,600 feet) they bored a hole down to 40 feet below sea-level, and took out the cores; and we have the cores on the Isthmus. This, however, will give you a pretty good idea of what these cores developed. This is Bas Obispo, where the heavy cutting would really commence.

For instance, that is an elevation of 50 feet. Here is an elevation of 40 feet. In other words, with a high level, 85-foot project, there would be the bottom of the canal (you understand, this is shown in section, like you would cut through an apple) right along through there; and above that the material would have to come out.

On a sea-level proposition this additional amount would have to come out, down here, down to 40 feet, minus 40. That boring developed fairly hard rock—I know that is rock, because I have cut a hole through there myself, and laid a track through there. Here there is fairly hard rock, very hard rock; here is another boring. These are kilometers 47, 46, 48; “very hard rock;” “very hard with quartz seams.” So, answering your question, you can say that probably with very hard rock that part of the canal would not necessarily need any revetment, assuming that these borings in here of rocks are the same—which is purely an assumption, but a very intelligent one.

Senator MORGAN. That is a safe assumption, is it?

Mr. STEVENS. I should say so; yes, sir. They have additional borings that are not shown here. These were simply put on every kilometer. At this point, kilometer 48, we found medium hard rock.

soft blue rock; then they struck medium hard rock; very soft black rock; conglomerate, with green talc; gray sandstone; hard rock; brown sandstone; hard greenish-black rock; soft, dark decomposed rock, reddish shade. That is the way it goes clear through.

Senator MORGAN. This is the line 40 feet below sea level?

Mr. STEVENS. Yes, sir; that would be the bottom of a sea-level canal of a depth of 40 feet. Now, you are getting up toward Emperador. Here is the big Culebra cut. Emperador is here. Now, we will find that line again.

There is 90, 60, 50, 45—here would be the bottom of your canal again, and all this mass would be taken out, in the case of the high level, down to this elevation. In the case of a sea level, it would be taken out down here [indicating]. Reading these again—I read that on the other—you see it says, "Soft blue rock; soft reddish rock; soft blue rock; hard blue rock; fairly hard and sandy talc; hard blue rock; very hard blue rock; hard rock, quartzite seams; very hard, many quartz seams; blue hard rock." So it goes on down—"medium hard, very hard blue rock; same with quartz seams." So you see that the strata of rock through there is very hard.

Senator MORGAN. Is that the 85-foot level?

Mr. STEVENS. Yes, sir. Here you have it half way between Emperador and Culebra—"hard conglomerate; very hard black, sandy talc; hard light-colored sandstone; soft black talc; sandstone; black talc sandstone; conglomerate talc sandstone; soft black talc; very soft black talc." Now, you see at that particular place the rock softens up.

Senator MORGAN. What is the last quotation here?

Mr. STEVENS. "Very soft black talc."

Senator MORGAN. Is that what you call indurated clay?

Mr. STEVENS. No, sir.

Senator MORGAN. It is not?

Mr. STEVENS. I have never seen any indurated clay south, I think, of San Pablo; and I am inclined to think that the material you spoke of the other day that was put into a bucket of water and dissolved was not indurated clay; I think that was clay from the Culebra cut. I noticed that General Ernst was quoted as the man who did it. I have not seen the General for two or three days. I am going to ask him where he got the sample from.

Senator MORGAN. Yes—well, he got it out of the well that the French dug there. Do you know where that is?

Mr. STEVENS. They dug wells at several places; I do not know exactly where.

Senator MORGAN. That is where he got it.

Mr. STEVENS. "Hard trap rock; medium hard blue tufa." That may be indurated clay at that point, but I never have seen it, and we have big cuttings through there now. This is the real Culebra cut, clear through here. You see, it is not very much raised from Emperador; and when you get west of here it immediately commences to drop. I have brought these maps and profiles over, Senator, thinking they might be interesting.

Senator MORGAN. Yes; they are very interesting. I wish we had a lot of them distributed through the Senate.

Mr. STEVENS. Well, you can get them. Those are the only ones I could pick up here; you know, I do not keep any of my records

here at all, because I have no connection with the engineering office here. That was simply for the benefit of the consulting board. We have on the Isthmus an endless amount of this stuff. "Soft and medium hard blue rock; a few hard embedded bolts. Material below this lock will require blasting before excavation."

It was necessary to use a diamond drill in boring that, Senator, which means that it was very hard. Now, where is 45 again? It is right here. Now, you simply see the strata platted here. That is soft rock, soft yellow rock, below that line. There is where you strike the real rock—"medium hard sandstone, a few bolts; hard sandstone; very hard lava; conglomerate; conglomerate; soft tufa." This will be the bottom of the canal, here.

Senator MORGAN. You are going down the hill now?

Mr. STEVENS. Yes, sir. Now, to explain, I will say that the 200-foot section comes through, of course, the heavy part of the cut. When you get down here, and the cutting gets so shallow, it widens out from here down to Pedro Miguel to 300 feet.

Senator MORGAN. Three hundred feet?

Mr. STEVENS. Yes.

Senator MORGAN. Now, we will take up that section. Do you apprehend any difficulties in digging the canal there, in that 300-foot section, as wide as is proposed by this minority report?

Mr. STEVENS. In the 300-foot section?

Senator MORGAN. Yes.

Mr. STEVENS. Difficulties of what nature?

Senator MORGAN. I mean, very serious engineering difficulties in widening the canal from 200 to 300 feet.

Mr. STEVENS. Oh, you mean in going from the 200 to the 300 foot width?

Senator MORGAN. Yes.

Mr. STEVENS. Why, I do not know of any, Senator. There is just so much more digging, but it is not as deep.

Senator MORGAN. More digging, and not as deep; and then it is flanked by hills on both sides?

Mr. STEVENS. The hills fall back farther, you know.

Senator MORGAN. Yes; but it is flanked by hills on both sides?

Mr. STEVENS. Oh, yes; the whole 8 miles is flanked by the mountains.

Senator MORGAN. Yes. Now, we will go on from that 300-foot cut. What is the next cut—the next width?

Mr. STEVENS. That brings you to Pedro Miguel. From Pedro Miguel for about 2 miles they widen it to 500 feet. That takes you to the vicinity of Miraflores, or a little below.

Senator MORGAN. You are now down the hill slope?

Mr. STEVENS. Oh, yes; away over on the Rio Grande.

Senator MORGAN. Does the digging there present any serious difficulties?

Mr. STEVENS. No, sir; not that I recollect. No; it does not. Excuse me if I locate myself on the map here. No; that 2 miles is through the section between and including Pedro Miguel and Miraflores.

Senator MORGAN. Now, from Miraflores?

Mr. STEVENS. It is given right here, I think.

Senator MORGAN. From Miraflores southward, what is the next width?

Mr. STEVENS. The next width is 1,000 feet or more. You strike the lake then. Understand, that 500 feet through that mile or two is really coming from the artificial part of the canal into the lake.

Senator MORGAN. That is Lake Sosa?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And that is a triangular lake; it is triangular in its general outline?

Mr. STEVENS. Yes, sir.

Senator MORGAN. You pass through that lake, and you get then to the depression between Sosa and Ancon?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And in that depression you put your tide lock?

Mr. STEVENS. No, sir. In that depression, you say? You are speaking of the—

Senator MORGAN. Between Ancon and Sosa.

Mr. STEVENS. You are speaking of the minority report?

Senator MORGAN. Yes, sir.

Mr. STEVENS. Well, then, we are all wrong. The line of the canal according to the minority report does not pass between the two hills.

Senator MORGAN. Oh, no; that is a fact. It passes to the westward of Ancon.

Mr. STEVENS. To the west of Sosa.

Senator MORGAN. To the west of Sosa?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Where do the minority put the tide lock?

Mr. STEVENS. They put two of their locks, which, of course, would answer that purpose, at this point—at La Boca, at Sosa.

Senator MORGAN. Two locks?

Mr. STEVENS. Yes, sir; and the other lock at Miraflores.

Senator MORGAN. Two locks at Sosa?

Mr. STEVENS. Yes, sir.

Senator MORGAN. What are the elevations of those locks? What is the lift?

Mr. STEVENS. Fifty-five feet is the sum of the two.

Senator MORGAN. Between the two?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Fifty-five feet elevation?

Mr. STEVENS. Of both locks; that is, the elevation of the lake is 55 feet.

Senator MORGAN. Yes. Now, does the minority propose any tide lock at all?

Mr. STEVENS. Only these locks. They expect them to answer for tide locks.

Senator MORGAN. But they provide no separate tide locks outside of these?

Mr. STEVENS. No, sir. There is another lock, you know, to make up the 85 feet, at Miraflores.

Senator HOPKINS. How far away is that?

Mr. STEVENS. About 4 miles.

Senator MORGAN. This is to the north of Sosa?

The CHAIRMAN. Will you be kind enough to mark those locks on there?

Senator KITTREDGE. He has marked them.

Mr. STEVENS. I do not think I have at Sosa, if you will excuse me.

Senator KITTREDGE. I know you marked this one at Gatun. You indicated, and I thought you marked them.

Senator MORGAN. Now, the minority have a lock at Miraflores; then they have two locks at Sosa?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Are they in a flight, one above the other?

Mr. STEVENS. At Sosa, yes, sir; duplicates.

Senator MORGAN. Duplicates?

Mr. STEVENS. There are four chambers.

Senator MORGAN. That will be four chambers?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And that is the end of their locking?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And from that point out it is a sea-level canal? The canal is dug in 40 feet below sea level?

Mr. STEVENS. Yes, sir.

Senator MORGAN. From that point out to the islands?

Mr. STEVENS. Three hundred feet in width.

Senator MORGAN. Three hundred feet wide and 4 miles long?

Mr. STEVENS. About 4 miles, to the 45-foot contour.

Senator MORGAN. Now, just for the sake of comparison and getting the idea into the minds of the committee, the majority report, the sea-level report—puts a tide lock in use in this depression between Sosa and Gatun?

Mr. STEVENS. No, sir; no, sir; they put nothing there.

Senator MORGAN. They put nothing there? Where do they put that tide lock?

Mr. STEVENS. They put it at Miraflores.

Senator MORGAN. And then they dredge from that point out?

Mr. STEVENS. Yes, sir.

Senator MORGAN. To 40 feet below sea level?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Out to the same point that you would reach, that the other half of the committee would reach. The twin locks at Sosa proposed by the minority, as I understand it, dispense with any tide locks for the purpose of regulating the inflow and the outflow of the tides?

Mr. STEVENS. Yes, sir.

Senator MORGAN. They dispense with it?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Whereas, on the other side, the majority put this sea-gate, or regulating lock, at Miraflores?

Mr. STEVENS. Yes, sir.

Senator MORGAN. How far back is that from the Sosa twins?

Mr. STEVENS. That is about 4 miles.

Senator MORGAN. Four miles back?

Mr. STEVENS. Yes, sir.

Senator MORGAN. So that the tide lock, as we call it—I believe that is the proper name for it—that is proposed by the majority of the committee would be about how many miles from the coast?

Mr. STEVENS. Do you mean high-tide line, or out at the 40-foot line in the bay?

Senator MORGAN. The 40-foot line in the bay.

Mr. STEVENS. It would be about 8 miles.

Senator MORGAN. Eight miles?

Mr. STEVENS. Yes, sir; say eight and a half.

Senator MORGAN. Yes. So that the distance—that is eight and a half miles, and there is 3 or 4 out into the bay—would be 11 or 12?

Mr. STEVENS. No; I mean eight and a half in all from Miraflores.

Senator MORGAN. In all?

Mr. STEVENS. Yes, sir.

Senator MORGAN. So that that eight and a half miles would be dug or dredged 40 feet below mean sea level?

Mr. STEVENS. Yes, sir.

Senator MORGAN. On the majority plan?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Would it be dredged from the twin locks at Sosa to the same depth on the minority plan?

Mr. STEVENS. There would be no dredging at all until you got within about a mile and a half of Miraflores; you would have the lake navigation there.

Senator KITTREDGE. I do not think you understood the Senator's question, Mr. Stevens.

Mr. STEVENS. No; I do not think I did.

Senator KITTREDGE. As I understand it, he asked if there was any difference between the plan of the majority and the minority from the twin locks seaward?

Mr. STEVENS. Only in the alignment. In one the line would pass between the two mountains, Sosa and Ancon, and in the other on the outside. Then there is a difference—no; there is the same width, 300 feet. No; there would be no difference. There is one point that you undoubtedly asked me about that I may have passed over. Under the minority report they propose to regulate the lakes by spillways between these mountains.

Senator KITTREDGE. Yes.

Mr. STEVENS. They are both rock, and the spillways, of course, are founded right on the rock. The rock there is very close to the surface.

Senator HOPKINS. Just indicate on the map where the spillway will be.

Mr. STEVENS. It will be directly between these mountains. You see, they put a dam across here [indicating]. The spillway would be right here.

Senator HOPKINS. Yes. Now, tell us something about the dimensions of that dam, please, and the character of it.

Mr. STEVENS. I can not tell you from my memory, now.

Senator MORGAN. The minority report shows the dimensions exactly. They were very careful in stating the dimensions.

Mr. STEVENS. Yes. I know it is very large, very wide, and all that; but I can not tell you exactly.

Senator HOPKINS. That is to be an earth dam, the same as the one on the other side?

Mr. STEVENS. Yes, sir; and I recommended to build it in the same way—to take the dredged material.

Senator MORGAN. Now we have passed through from one side to the other in the examination of the axis of the canal. Suppose that a sea-level canal were dug between the same points, from the 40-foot

contour in the Bay of Limon out to the islands in the Bay of Panama, on the plan that the majority propose; what would be your opinion as to the comparative safety of navigation upon the two canals, taking the same size ships, taking the largest-sized ship that could be expected to go through?

Senator HOPKINS. It is now quarter of 1 o'clock; suppose we adjourn until half past 2, and then take up that question?

Senator MORGAN. Let me get this answer, and then we can adjourn.

Senator HOPKINS. Yes.

Mr. STEVENS. To give you my opinion I would necessarily have to give you some reasons why I have that opinion.

Senator MORGAN. Of course.

Mr. STEVENS. And that involves going through in detail and showing you—which I have summarized here—the comparison of widths between the canal on the other side, to show you the widths that are proposed in the majority report.

Senator MORGAN. Yes. What I want to get at is your opinion as to the comparative safety of ships in the respective canals as they are proposed to be dug by the minority and the majority.

Mr. STEVENS. My opinion is that a very large ship could never be assured of getting through a sea-level canal of the dimensions reported without grounding, unless she ran at such speeds as would practically destroy the usefulness of the canal, for this reason: That out of the 49 miles there is over 29 miles that is only 200 feet wide; and you can see from the map that it is more or less tortuous in direction. I think that this situation would be accentuated by the immense number of small streams carrying flood water directly into the canal at the depths that they would, from 30 to 150 or 160 feet. They are constantly carrying in detritus that would make shallow bars that would very soon render the navigation of such a canal impracticable for large ships, and sooner or later for all ships, unless there were a fleet of dredges kept constantly working from one end to the other to keep it open.

Senator MORGAN. Right there let me ask you this question: We have a cut there 200 feet wide through Culebra Hill?

Mr. STEVENS. Yes, sir.

Senator MORGAN. The bottom of it is rock, alternating with dikes of other material that come up between. Is it practicable to make the floor of such a canal so smooth as to make dredging inexpensive or comparatively inexpensive? Can you make the floor of it smooth?

Mr. STEVENS. Why, yes, sir; certainly. You would expect to make the walls smooth, anyway, by channeling. You mean to make the bottom of the canal so smooth that it can be dredged?

Senator MORGAN. Yes.

Mr. STEVENS. Oh, yes.

Senator MORGAN. There is no difficulty in that proposition?

Mr. STEVENS. It can be done all right.

Senator MORGAN. Then I will dismiss that subject from my mind, at least. So that as to dredging a sea-level canal and dredging an 85-foot elevation lock canal, it is about the same in the one case as in the other?

Mr. STEVENS. Over the same length of distance?

Senator MORGAN. Yes.

Mr. STEVENS. But in the one case you have 5 miles 200 feet, and in the other you have 21 miles.

Senator MORGAN. That is the difference?

Mr. STEVENS. That is the difference.

Senator MORGAN. You have 21 miles to take care of?

Mr. STEVENS. You have 21 miles of 200 feet in the sea-level canal, and only 5 miles in the high-level canal.

Senator MORGAN. Twenty-one miles of dredging against 5 miles?

Mr. STEVENS. In those narrow channels.

Senator MORGAN. Yes.

Mr. STEVENS. Then you would have, in the case of the sea-level canal, 18.85 miles—almost 19 miles—of 300 feet width. In the high-level canal you would have 6.8 miles only.

Senator MORGAN. Yes. Is there any material, practical difference in the curves in the two proposed canals, the lock canal and the sea-level canal?

Mr. STEVENS. Oh, yes, sir. All the way up through the lakes, of course, your curvature cuts very little figure on account of your wide channel. In the lake navigation the wider your channel your curve immediately becomes easier, because you have such a width in which to make your swing.

Senator MORGAN. Yes; of course.

Mr. STEVENS. Whereas in the lower channel of the sea-level canal you are confined to this narrow 200-foot channel all the time.

Senator MORGAN. Yes. So that if the curvature was the same in the two cases in the actual line of the canal, the advantage would be in favor of the larger body of water?

Mr. STEVENS. Oh, every time, of course.

Senator MORGAN. Is there any practical difference in those parts of the line as to curvatures, for instance, through Culebra Heights, Emperador Heights?

Mr. STEVENS. Not through the heavy part of the canal.

Senator MORGAN. They both run on the same curves?

Mr. STEVENS. Yes; on the same curves. There was a question raised in the Board (and I am not clear whether the minority report or either report indorses it) to the effect that there should be no curves in the canal, properly speaking; not as you lay them out on a railroad.

(The committee thereupon took a recess until 2.30 o'clock p. m.)

AFTER RECESS.

STATEMENT OF JOHN F. STEVENS, ESQ.—Continued.

The CHAIRMAN. Senator Morgan, do you not think we had better continue along the line that was interrupted at recess? You and Mr. Stevens were making it interesting, and I think we had better proceed and finish up the minority report.

Senator MORGAN. I shall have few questions to ask Mr. Stevens about the situation there now. I think I comprehend it, and I suppose the members of the committee all comprehended everything about it, although perhaps they have not studied it as closely as some of us, for many years, at least. I think I am pretty well through with my line of questioning.

I asked Mr. Stevens a question the other day that I would like him to make a statement about. "Take the present income of the railroad and apply that to the payment of a sum of money bearing interest at the rate of 2 per cent, what would be the capitalization upon the basis of the present income of the canal, at 2 per cent upon the sum, whatever it is, that would be required?" He answered my question the other day in writing. I suppose you have the question right in your mind? Perhaps I have not stated it exactly.

Mr. STEVENS. My understanding of the question was, if I recollect rightly, "taking the net income of the railway?"

Senator MORGAN. Yes.

Mr. STEVENS. For instance, applicable to dividends, if they were proposing to pay dividends, or interest on bonds. I do not recall just now what the net income was, but I think the assumption was that it was about \$700,000—

Senator MORGAN. I think you put it at that, about \$700,000; and you put the capitalization that would be required, at 2 per cent, to cover the investment, at twenty millions of dollars. In other words, that the canal as it is there now (free from debt, of course), out of its present earnings, over and above the charges for maintenance and conduct, would yield 2 per cent on twenty millions of dollars, that 2 per cent being our rate of interest, practically. I suppose the value of the railroad at present would be considered as twenty millions of dollars, if the debts were all paid off, the outstanding bonds, and so on. Now, would you expect that in the future the income of the railroad would be increased over what it is now?

Mr. STEVENS. After the construction of the canal?

Senator MORGAN. Up to the date of its completion, I will say, first.

Mr. STEVENS. Well, I do not know that I could answer that, for two reasons: One is that there will undoubtedly be always, until a canal is completed, a fair amount of commercial business. This will be increased by the work on the canal. It certainly will not become less. Perhaps the Panama Railroad will be shortly subject to competition by the northern route, the Tehauntepec Railway. How far that competing road will have its effect on the commercial business there, I can not say.

Senator MORGAN. Assuming that the state of progress that has been made since that railroad was built is continued, as well as the commercial development and commercial intercourse between the countries that are supplied with ocean navigation on the Pacific and on the Atlantic, would you not suppose that the income of that railroad would be increased proportionately, say, in the next fifty years?

Mr. STEVENS. No, sir.

Senator MORGAN. Why not?

Mr. STEVENS. Well, I am not a statesman, and not much of a political economist. I can not understand, when we do not get very much of the trade of the eastern coast of South America, why we should naturally expect very much on the west coast.

Senator MORGAN. I do not propose to go into any tariff argument about it. I think I know exactly where the trouble is, but I do not want to go into that, you know. I do not want to assume that we are going to have an era of free trade, because I do not think we are. But the natural growth of commerce, the world over, is very large.

Mr. STEVENS. Yes.

Senator MORGAN. Notwithstanding its development on the eastern coast of South America has been comparatively slow. But, taking now the increased facilities of commerce for the exportation of very heavy material, that otherwise would never float into commercial channels at all, in consequence of the rapidity and cheapness of the transportation, would you not suppose that this railroad property there, if it stood alone, and not in connection with the Tehuantepec road or any other road that might be made through Guatemala or elsewhere, it would increase in the next fifty years in proportion to its increase in the past fifty years?

Mr. STEVENS. I should look for an increase, but I can not say at what rate it would increase.

Senator MORGAN. Would you look for an increase of double the present commerce?

Mr. STEVENS. I should not want to be called on to state definitely just what the increase would be. I think there would be an increase.

Senator MORGAN. But if such an increase should occur, then the capitalization would be \$40,000,000?

Mr. STEVENS. It would increase in proportion to its net earnings.

Senator MORGAN. It would be double the present income, which would be \$40,000,000. That would cover the cost of the purchase of it, and make it a good property, at \$40,000,000.

Mr. STEVENS. It would seem so.

Senator MORGAN. When the canal is completed, it is the general supposition that that railroad will be thrown away, and that except for merely local traffic it would hardly be worth keeping up?

Mr. STEVENS. I see very little use for it once the canal is completed.

Senator HOPKINS. Right there: If the canal is constructed as suggested by the minority of the Commission that has been down there, will not that destroy a large part of the road itself—I mean, physically destroy it?

Mr. STEVENS. Miles of it.

Senator MORGAN. I was coming to that in a moment, when I got the other proposition squarely before the committee. So that in contemplating the future of this canal and the financial situation that it will create, we must calculate on throwing away property that is now worth \$20,000,000, and if its income should be doubled by the time the canal is completed we will throw away \$40,000,000 worth of property. That, then, will be added to the expense of any canal through Panama, whether a lock canal or a sea-level canal—the throwing away of \$40,000,000 that we necessarily invest, besides what we are going to invest, or are obliged to invest in making the changes of location?

I wish to ask you about these benches that run along the diggings, through, for instance, the Culebra Heights. Are they wide enough to sustain railroad beds?

Mr. STEVENS. The benches as proposed?

Senator MORGAN. As they exist. In the diggings you have left benches.

Mr. STEVENS. Yes, sir.

Senator MORGAN. They have been left?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Are they wide enough to sustain railroads?

Mr. STEVENS. That is, work tracks, to do the digging on?

Senator MORGAN. Yes.

Mr. STEVENS. Yes, sir.

Senator MORGAN. So that it is not necessary, really, that the railroad that is carried through this cut should be built right on the berm of the canal? You could carry it up to the next bench, if you choose?

Mr. STEVENS. Oh, yes, sir.

Senator MORGAN. So that, whether it is a sea-level or a lock canal, there will be through all of the cuts facilities for building railroad lines?

Mr. STEVENS. On the slope of the cut; on the benches in the slope?

Senator MORGAN. Yes.

Mr. STEVENS. Yes, sir.

Senator MORGAN. All along through?

Mr. STEVENS. Yes.

Senator MORGAN. Those roadbeds will be good beds?

Mr. STEVENS. Oh, undoubtedly.

Senator MORGAN. Now, then, in changing the location of the railroad, that ought not to be finally changed, I suppose, until you have got the benches constructed there at such elevations on either side of the diggings as will enable you to haul your trains, of course, conveniently at proper gradients?

Mr. STEVENS. Yes.

Senator MORGAN. I think I noted in the proposition of the minority of the board that the bed of the railroad, as at present located, would have to be changed, and that it would pass through the ridge that makes the abutment of the locks at Gatun. It would have to pass through that ridge?

Mr. STEVENS. Yes; it would either have to pass through that ridge or go over it.

Senator MORGAN. Is it practicable at present to carry the railroad right along up the right bank of the Chagres and through these cuts? Is it practicable to make a change at the present time?

Mr. STEVENS. Not without building a new roadbed.

Senator MORGAN. Not without building a new roadbed?

Mr. STEVENS. No, sir.

Senator MORGAN. You have got the great gap cut down to a certain depth and are proceeding to cut it down, and indeed you have got railroad lines or tracks——

Mr. STEVENS. But not lines of the Panama Railroad proper.

Senator MORGAN. I know; other tracks, though, that are usable for transporting the soil?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Take from one side to the other of that 8-mile cut there; is it in such condition as that the Panama Railroad could at present be located through that cut?

Mr. STEVENS. The track could not be laid without a great deal of work, to get from point to point.

Senator MORGAN. The minority report seems to provide for the crossing of the canal by the railroad at some point about Bohio, or above Bohio, when the final location is made. When you showed the route of the railroad, to make room for this lake it seems that they go up on the right bank of the Chagres River and cross over to the left bank, and then get into the track that they have got now, which winds around this Culebra Hill.

Mr. STEVENS. That is not my impression, Senator.

Senator MORGAN. It is not your impression?

Mr. STEVENS. I would not recommend it in any case.

Senator MORGAN. What is your impression about where that railroad track is to run?

Mr. STEVENS. It should run east, or on the right bank of the Chagres, all the way, on the valley of the lake.

Senator MORGAN. All the way through?

Mr. STEVENS. Clear through the cut to Panama. I would not attempt to cross the canal with it at all.

Senator MORGAN. That was my difficulty. Evidently, I think, the minority report here provides for the crossing of this lake by this railroad, and I did not understand why that was necessary.

Mr. STEVENS. I would not advocate putting any bridges or anything like that across.

Senator MORGAN. It would be impracticable. So that when we come to the final location of that railroad, the permanent location of it, if we may say so, it must be on the right bank of the Chagres River?

Mr. STEVENS. I should certainly say so; yes, sir.

Senator MORGAN. And it would cross the river on the dam at Gamboa, if there was one, and if not, on a bridge?

Mr. STEVENS. Yes, sir.

Senator MORGAN. That, then, means that whether you have a sea-level route or whether you have a lock canal this railroad, to answer the purposes for which it is designed, both in assistance of the canalization of that country and also transporting commerce, must go up the right bank of the Chagres and cross it about Gamboa, or at Gamboa, and then on through on that same side of the canal until it gets down to the coast?

Mr. STEVENS. Yes, sir; that would be my idea.

Senator MORGAN. Then either plan, the sea-level canal or the lock canal, implies that that railroad is to be taken up and built through, from Colon to Panama, along the right bank of the Chagres River, thence right along on the same side of the canal until you get to Panama?

Mr. STEVENS. That is my understanding; yes, sir.

Senator MORGAN. That would have to be done, I suppose, within the next five years?

Mr. STEVENS. Well, the roadbed would necessarily have to be prepared during the construction of the canal; but you would not necessarily lay the track until just before you were ready to destroy the railway—that is, to finish the canal.

Senator MORGAN. So that the transference of this railroad from one roadbed to another, and its maintenance, from this time until the canal is completed, is likely to involve very heavy expenditures?

Mr. STEVENS. Yes, I think both reports have covered their estimated cost. It is included in their totals.

Senator MORGAN. What grade would you think you could afford to have through these cuts for a railroad that would answer all the purposes that this road is designed for?

Mr. STEVENS. Well, as I said before, I can see very little use for a railroad after the canal is built. Therefore I would necessarily build a comparatively cheap line.

Senator MORGAN. A steep line?

Mr. STEVENS. A cheap line. I would use moderately sharp curvature and heavy grades. I should think $1\frac{1}{2}$ to 2 per cent would be allowable.

Senator MORGAN. A line that would be 50 feet above the surface level of the canal would not be too high, would it?

Mr. STEVENS. I do not see the necessity for putting it that high. The higher you go in a mountainous country, as a rule, the sharper the slopes and the more the expense of construction.

Senator MORGAN. There is no practical difficulty in building a railroad through—no engineering difficulty?

Mr. STEVENS. No, sir; nothing but what can be done within reason.

Senator MORGAN. Many railroads are built over worse ground than that?

Mr. STEVENS. Undoubtedly.

Senator MORGAN. That is all I desire to ask. Later on I shall have a question to ask Mr. Stevens about another matter.

Senator HOPKINS. Was not Mr. Stevens after the recess to go on and give a full explanation of the majority report and what they suggested?

Senator KITTREDGE. I would like to ask one question, if I may: What does the minority report of the consulting engineers recommend in regard to the minimum usable dimensions of the locks?

Mr. STEVENS. Nine hundred feet long and 95 feet wide, according to my recollection.

Senator KITTREDGE. I noticed in the report of the board this statement: "As a basis for all plans, the board resolved by 11 affirmative votes and 2 negative that the locks should have as minimum usable dimensions a length of 1,000 feet, a width of 100 feet, and a depth of 40 feet."

Mr. STEVENS. I think the minority report made different recommendations afterwards. I am not able to put my hand on it in this report, but that is my recollection of it. I may be able to find it here. As a matter of fact, most men who are familiar with locks prefer in locking a ship through to have very little clearance between the side of the ship and the side of the lock wall.

Senator KITTREDGE. That is, no doubt, true; but I assume that the recommendation of the board was to enable the locks to accommodate the largest ships that might in the future be constructed.

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. That was the purpose?

Mr. STEVENS. They have gone into it very thoroughly here in their report—very exhaustively, at least.

Senator KITTREDGE. Why does the minority report of the board say 900 feet?

Mr. STEVENS. I could not tell you that.

Senator KITTREDGE (continuing). Instead of a thousand feet, as all but two seem to state in the report.

Mr. STEVENS. I do not seem to find that now, but that is my recollection. Of course, I may be wrong. My recollection is that they recommend 900 feet usable length and 95 feet breadth.

Senator KITTREDGE. I can find it later just as well. You have thus far said nothing about the cost, Mr. Stevens, of the construction of the

canal recommended by the minority of the consulting engineers, or of the time that it would take to build the canal.

Mr. STEVENS. As I said in commencing this programme to-day, I did not consider myself delegated to go into all those matters. The consulting board, I understand, was created to furnish information to the Commission and to Congress. I have, however, checked independently of the board, and independently of anyone, an exactly similar proposition, before any figures that the board had made were available, and my figures correspond very closely with those that are given here.

Senator ANKENY. You mean in the minority report?

Mr. STEVENS. The minority report; yes, sir. In other words, my figures at the outset were 150 millions, and I believe their estimate here is 139,700,000.

Senator KITTREDGE. Does that mean \$150,000,000 in addition to the amount already appropriated?

Mr. STEVENS. As the work stands to-day, with the cost of the equipment that has been ordered in.

Senator KITTREDGE. One hundred and fifty millions in addition to that?

Mr. STEVENS. No; the cost of the equipment that has been ordered up to this time would be included in that.

Senator KITTREDGE. Up to date 21 millions have been appropriated for construction purposes; is the 150 millions you have mentioned to be in addition to that sum?

Mr. STEVENS. Only in part, I think. I could not tell without going back to my notes in regard to that. I do not know that I kept my notes. I do not think I did. You see, Senator, I have had to depend, like all the rest of the people, on the figures that these men have made, largely.

Senator KITTREDGE. I understand. I simply wanted to get your ideas of these matters as we go along. Can you tell us what your recollection is as to what part of the \$21,000,000 already appropriated is to be included in this 150 millions?

Mr. STEVENS. I could not tell you that. I do not recall now.

Senator MORGAN. Suppose we take up the sea-level canal.

Senator KITTREDGE. May I ask another question? What about the question of time in the construction of the canal recommended by the minority of the consulting engineers?

Mr. STEVENS. In running through the details, before they made their report, of a plan along similar lines, and making the allowances I felt justified in making, I figured about one year less than they have. I think they figured eight years or nine years, and I figured, I think, seven. Possibly their estimate is a safer estimate than mine.

The CHAIRMAN. Mr. Stevens, suppose you take the report of the majority of the Board, and go through it, having gone over this minority report pretty generally with the committee. I think we had better take that up right from the report itself. Have you a copy of it there?

Mr. STEVENS. Yes, sir. I was looking to find that statement of the dimensions that we had this morning. If I had known the lines which this talk would take, I would have gotten things in concrete shape, so that I could answer questions more accurately. The fact

of the matter is that I have not read either of these reports for several days, and I have only read them twice each. I have taken no time to prepare. Along what line do you wish me to proceed, Mr. Chairman?

The CHAIRMAN. I think you had better read along, and let the gentlemen present ask you any questions they may desire to put.

Senator HOPKINS. Why not first show us the canal as it will be if constructed along those lines, and then elaborate it along practically the same lines as you did the minority report?

Mr. STEVENS. I will show you, as far as I can, on this map. The map is not complete for this project.

Senator GORMAN. Is there any better map obtainable?

Mr. STEVENS. I do not know of any better map.

The CHAIRMAN. They sent that to us from the Commission as the best they had.

Mr. STEVENS. You understand that the maps to accompany these reports have none of them been filed yet.

As nearly as possible I tried to illustrate this morning the changes, or rather the definite location that the board—and when I say “board” I mean the sea-level project—reported on, going north, out to sea, here at Colon, and leaving the present line of the canal, which you understand is here at about this point [indicating on map].

Senator GORMAN. Name the points as you mention them.

Mr. STEVENS. Well, we will call it near Mindi. It is hard work to state specifically, because the distances are so long here, and they have not given any definite points, except a few. Swinging out, about as indicated, cutting through this point and making the terminus of the canal proper, the 41-foot line, about where my ruler is on the map here.

In other words, they come through more like that [indicating on map], forming that channel as shown on this list, from Limon Bay, that meets the outer harbor line, for a distance of 4.07 miles, 500 feet wide; that 4.07 miles extending about to Mindi. I will refer to this other map on the table here for distance, because it is the only one that has the miles mentioned on it. [After consulting map.] Yes; extending to Mindi. The breakwater would lie outside of that, paralleling this channel, clear out to the harbor line. My recollection is that they put a short breakwater on the inner side, too, at Mindi.

Senator KITTREDGE. That breakwater is near the present town of Colon or Cristobal.

Mr. STEVENS. Right out through the harbor. It runs in front of the town. From 4.72 miles—that is, at Mindi—to 16 miles, which is 12 miles, following the present line, they propose to make the canal 150 feet wide on the bottom.

Senator KITTREDGE. And how wide at the surface of the water?

Mr. STEVENS. I think their slopes are 2 to 1; that is, for every foot in rise you would fall back 2 feet. With a 40-foot cutting you would fall back 80 feet on either side, or 160 feet on both sides. One hundred and sixty added to 150 gives you 310 at the surface of the 40-foot cutting.

That same proposition holds good right through, clear through the mileage to the Sosa locks, with varying width all the way through.

Senator KITTREDGE. Do you mean the Sosa locks?

Mr. STEVENS. I mean the Miraflores locks, clear through. For instance, commencing again from Limon, 4.7 miles, your width would be 500 feet. I am speaking now of the bottom; from 4.7 to 7 miles, 150 feet; from 7 miles to 16, 150 feet; from 16 miles to 17 miles, 200 feet—I am dropping the decimals; from 17 to 23 miles, 150 feet; from 23 to 24 miles, 150 feet; from 24 to 25 miles, 200 feet; from 25 to 27 miles, 150 feet; from 27 to 31 miles, 200 feet; from 31 to 32 miles, 200 feet.

Senator KITTREDGE. Let me ask you: You have now reached the Culebra cut?

Mr. STEVENS. No, sir. We will reach the Culebra cut proper at Obispo, at 31. Did I get that far? Yes. From 31 to 44 miles, 200 feet. That includes the entire Culebra cut, and through nearly to La Boca, 200 feet; that is only a short fraction. From 44 to 45 miles, 300 feet; from 45.37 to 45.50 miles, 300 feet; from 45.50 to 45.87 miles, 350 feet; thence to the Pacific terminus, 300 feet. The aggregate would be, then, for the sea-level canal, that you would have for 4.72 miles a width of 500 feet.

Senator GORMAN. On the surface or on the bottom?

Mr. STEVENS. On the bottom. You would have 3.9 miles 300 feet wide. You would have 18.8 miles 200 feet wide. You would have 21 miles 150 feet wide, with a total length of the canal of 49.3 miles. It is hard to carry this in your head.

With a lock canal you will have 19.5 miles 1,000 feet wide or more. You will have 3.8 miles 800 feet wide. You will have 12.7 miles 500 feet wide; 6.8 miles 300 feet wide; 5.3 miles 200 feet wide; with a total length of 49.7 miles.

Senator KITTREDGE. Did the first figures give the width of the canal at the surface of the water or at the bottom?

Mr. STEVENS. At the base of the excavation. At the bottom of the canal.

Senator KITTREDGE. What were the last figures? They referred to the surface of the water, did they not?

Mr. STEVENS. The last ones that I read?

Senator KITTREDGE. Yes.

Mr. STEVENS. Those were the widths of the lock canal.

Senator KITTREDGE. They refer to the surface of the water, do they not?

Senator DRYDEN. They refer to the bottom.

Mr. STEVENS. They refer to the bottom. When I say a thousand feet or more, that means through the lakes. It might be 2 miles wide, you know.

Senator HOPKINS. With this canal, how much deeper do you go than with the lock canal?

Mr. STEVENS. With the lock canal, as proposed by the minority, you go the difference between plus 40 and minus 40, which is 80 feet; or plus 45 and minus 40, which is 85 feet.

Senator SIMMONS. The whole length of the canal, or only part?

Mr. STEVENS. From the Gatun dam to the Pedro Miguel lock, under the minority report; at the sea level from the outer harbor line to Gatun on the north line, and from the outer line to Sosa on the south end.

Senator GORMAN. The difference being whether you cut off that point or not?

Mr. STEVENS. That is all the difference. The minority made a swing out there to avoid a lot of expensive rock, which they do not get here.

Senator KITTREDGE. What was the reason of the majority in going through that point; did they have any reason that you know of?

Mr. STEVENS. Nothing except to get an absolutely straight line.

Senator DRYDEN. In the sea-level project they propose to erect tidal dams and one or two tidal locks?

Mr. STEVENS. Yes, sir.

Senator DRYDEN. How do they get the boats over those?

Mr. STEVENS. By the regular locks; just like any lock.

Senator DRYDEN. So that they would not avoid the necessity of lifting the boats up?

Mr. STEVENS. There would be times when you would lift them, and times when you would drop them.

Senator KITTREDGE. And times when they would run through on the tide?

Mr. STEVENS. Yes. You would lock, but not nearly as much as you would to lift the boat clear up.

Senator KITTREDGE. There would be times when there would be no locks either way?

Mr. STEVENS. Undoubtedly; yes, sir.

Senator HOPKINS. You estimated the length of time that it would take to go through the locks on the lock canal; how long a time do you estimate that it will take under the sea-level canal to go through the locks?

Mr. STEVENS. To go through the locks? I should not suppose that it would take over fifteen or twenty minutes. I understand that at the Poe lock on the St. Marys Canal they put ships through in nine minutes.

Senator MORGAN. Is that the British lock?

Mr. STEVENS. No, sir; the Poe lock is the American lock. I can not think of anything more through this stretch of the canal up to Gamboa to call your attention to, with the exception of a mass of detail that is rather hard for you to carry in mind, concerning the diverging channels. It is proposed to dig new beds for the larger and more important streams all the way, parallel with the canal, to keep them out of the canal proper; to make a new channel for them on either side of the dikes. For instance, all these streams that come in here [indicating on the map]. Still farther back here are all those strong influent streams that come in here [indicating on the map]. They take these down through these channels, dig them from one to the other, enlarge the old French channels, making a diversion of their waters, and eventually discharge them away across the country here, into Admiralty Bay, I think they call it.

Senator HOPKINS. They make new beds for all the rivers?

Mr. STEVENS. All the large ones; yes, sir.

Senator GORMAN. Is that estimated for in this minority report?

Mr. STEVENS. There is an estimate for it.

Senator GORMAN. Is it included in their total?

Mr. STEVENS. Yes, sir.

Senator HOPKINS. This is the plan of the majority, not of the minority.

Mr. STEVENS. This is the plan of the majority.

Senator HOPKINS. How do you dispose of the Chagres River under the sea-level plan?

Senator KITTREDGE. He is coming to that after a little while, I think, Senator.

Mr. STEVENS. They dispose of that by bringing it through regulating sluices in their high dam. I think they have stated it in their report better than I can. As far as the regulation of the Chagres River at that point is concerned, they undertake to put up this very high dam. You will find it on page 26 of their report.

Senator DRYDEN. At what point did they put that dam?

Mr. STEVENS. About one-third above the prism of the canal. Right there between those mountains. I believe the dam is to be about 180 feet high, or something like that, and half a mile long.

Senator HOPKINS. What is to be its width?

Mr. STEVENS. Its thickness?

Senator HOPKINS. Yes; its thickness.

Mr. STEVENS. My recollection is that they propose a masonry dam. By holding back this water, you understand, they will be able theoretically to let it come whenever they want to, and in such quantities as they want—that is, the floods are never so continuous that they would fill this dam, or anywhere near it, so that there is no danger of the water going over the top. In other words, they hold back this reservoir until this flood is over, and then, by opening this spillway or the regulation gates, they would let just as much or just as little come through as they please.

Senator MORGAN. If I understand it, the canal prism is to take care of all that water?

Mr. STEVENS. Yes; that is my understanding.

Senator MORGAN. And the diversion that is mentioned is to take care of the water of the smaller streams?

Mr. STEVENS. Yes, sir. To quote from the third paragraph, on page 26 of the report of the majority of the Board:

* * * So that if 15,000 cubic feet of flood water per second from the Chagres be permitted to enter the canal prism at Gamboa, the resulting current, if the entire quantity admitted flows in one direction, will be but 1½ miles per hour, a negligible quantity, so far as its effects upon navigation are concerned; but the plans for a sea-level canal contemplate a provision that would permit the discharge through the canal prism and regulating sluices near the tidal lock on the Pacific side of approximately one-third of this Gamboa discharge.

In other words, they intend to use all of that, all this flood water, in reduced quantities, so that it will not affect the navigation of the canal. It is provided for in this way: There is no obstruction going out to the ocean, and that is why they put a spillway over there, that I will explain.

Senator KITTREDGE. That is, a spillway in connection with the tidal lock at Miraflores?

Mr. STEVENS. Yes; near Miraflores. This diversion here that I outlined on the map is continued through on the east side. On the west side there are some very large streams that come in, the Trinidad, I think, being the largest, that they intend to bring right into the Chagres River, and by a system of dikes to keep them from going

to the canal. I have not gone into that matter thoroughly enough to know the exact details, but they are explained in the report.

The other streams above it, on the west side, clear up through the crest of the mountains, they propose to take care of in various ways. As to the more important of them they intend to build dams, or plan to build dams, and let the resulting basins that are formed by these dams fill up to a certain point, and then they go backward. In other words, they run water up hill. The watersheds are right here [indicating on map].

Senator MORGAN. You run the water across the watersheds?

Mr. STEVENS. Exactly. There are several of those that I found in the report that are back in the jungle, at points that I have never visited. We have no particular surveys, no borings at all to indicate their size, character, or foundations, or anything of the sort.

Senator KITTREDGE. Are there any records in your office on the subject?

Mr. STEVENS. Not that I am aware of. The only record that I know of is a contour map from which an engineer can make a rough estimate of the size of the dam.

Senator MORGAN. Do they furnish to the Government here in their report a detailed statement of what these various works would be outside of the canal?

Mr. STEVENS. I understand they do. Those are the plans that we have not got.

Senator MORGAN. Yes.

Mr. STEVENS. That same scheme of taking care of influent water holds all the way through the canal. I know in the estimates there are \$3,500,000—I think that is the estimate; the record will correct me if I am wrong.

Senator HOPKINS. For taking care of the various rivers?

Mr. STEVENS. Yes, sir; including these dams and spillways. I would not attempt to guarantee that estimate. I would not care to express an opinion, further than to say that it would seem to me, in the absence of accurate data for borings, and special surveys, that there is a great deal of guesswork in it. In other words, I think, with all due respect to the men who made it, that it is an assumption that I do not believe their data warrants. To put it plainly, to my mind going back there and establishing dams means roads, sanitation, policing, and things like that. That estimate is just as liable to be three times as much, as it is to be what they have got it, because we are going into the unknown.

Senator MORGAN. If the regulation works on either of these important streams running into the Chagres should fail, that would mean disaster?

Mr. STEVENS. If the Gamboa dam should fail, the canal would be wrecked in ten minutes.

Senator MORGAN. How about these small streams, the Trinidad and so on?

Mr. STEVENS. They do not interrupt navigation for the time being. They might bring down an immense amount of detritus.

Senator MORGAN. This system would be built, under the care of the management of the canal, including the number of outlets and dams that are intended to regulate these waters, to protect the canal against the influent waters?

Mr. STEVENS. Yes, sir.

Senator MORGAN. The care of these works would be in the hands of the employees—

Mr. STEVENS. I think I see the idea that is in your mind, Senator. Of course it is an axiom in the maintenance of a railway that you want to concentrate everything you can under the eye of the man who is responsible for the maintenance. In other words, we say that a section man never sees anything outside of the end of a tie. That is unfortunately correct. In other words, if we have a bad washout, through something just outside of the line that diverted the water to it, it is not reported, because the man in immediate charge does not understand the importance of it.

Senator HOPKINS. The breaking away of the dam of the Chagres River would destroy the canal instantly?

Mr. STEVENS. Yes, sir. It would put it out of commission, without question. You can imagine what the effect would be of letting 150 feet of water, less than a quarter of a mile or a third of a mile away, right into the canal; although, of course, it is contemplated to build such a dam as never would, by any possibility, let that happen.

Senator KITTREDGE. What are the conditions for the construction of a dam in that vicinity?

Mr. STEVENS. They are very good. At 50 feet you have solid rock, and also on the wings.

Senator KITTREDGE. What is the character of the rock at that point?

Mr. STEVENS. It is a trap rock; a fine rock foundation. It is all right.

Senator KITTREDGE. Is there any more danger, if a dam were constructed at that point, of its breaking away than there would be with any dam under similar circumstances?

Mr. STEVENS. No, sir; I do not think so, outside of the question of earthquakes.

Senator KITTREDGE. Do you know of any earthquakes having occurred in that country?

Mr. STEVENS. I have not got any record of any earthquakes. We have an earthquake machine at Ancon—that is, at Panama—but it has only been running for a few months.

Senator KITTREDGE. Did you ever see the straight arch in the old church at Panama?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. Do you know how long that has been there?

Mr. STEVENS. I suppose two hundred years or more.

Senator KITTREDGE. Any serious earthquake would have destroyed that, would it not?

Mr. STEVENS. Well, that is a mystery to me—how it stands. I have heard the explanation, but it does not satisfy my mind. I can not explain it from an engineering standpoint—why it does stand.

Senator KITTREDGE. Is not that quite a convincing argument that earthquakes never happen at Panama?

Mr. STEVENS. Decidedly, to my mind. I can not conceive of an earthquake of any severity at all but what would destroy that arch.

Senator KITTREDGE. So that there is not any danger of the dam at Gamboa being destroyed by an earthquake?

Mr. STEVENS. I would not say that there was no danger, but I suppose there is no place in the world but what is liable to have an earthquake. That is one reason why I made the statement this morning that I preferred an earthen dam to a masonry dam anywhere, because I do not think an immense earthen dam could be destroyed by an earthquake.

Senator DRYDEN. I should like to get your views as to the relative advantages of these two systems of canals to commerce, as to expense and time in passing through and also as to war vessels.

Senator KITTREDGE. Would it not be better to let him go ahead on this line until he gets through?

Senator DRYDEN. I thought he had come to a point where he could stop.

Senator KITTREDGE. I do not think he has finished.

Senator DRYDEN. Before the conclusion of his statement I would like to ask that.

The CHAIRMAN. Go right along and get through with this branch of the subject. I think that would be better.

Mr. STEVENS. I do not know of any other point that I can bring out.

The CHAIRMAN. You have only got about two-thirds of the way across as yet.

Mr. STEVENS. We have got up to Gamboa.

The CHAIRMAN. Yes.

Mr. STEVENS. That is at mile 31, as I recollect. From this point to the Culebra cut, so called—that is, through the summit cut—they propose the same width as the minority people—200 feet.

The CHAIRMAN. That is, at the bottom of the canal?

Mr. STEVENS. Yes, sir. In that respect the passage through that 4 or 5 miles, or 8 miles, rather, would be the same, with the exception that for a certain distance from Obispo to up near Las Cascadas, the minority people make it 300; and for a certain distance at the west end, near Paraiso, they made it 300. In other words, they shorten their 200-foot stretch by about 3 miles.

We come through Las Cascadas, Emperador, and Pedro Miguel, where we leave the heavy cutting between there and Miraflores, and we drop down to the tidal flats. In other words, extreme high tides run up these streams about to Miraflores.

Here, as I explained this morning, at Miraflores, or in that immediate vicinity, the majority report takes an entirely new location, straight from Miraflores, passes between Ancon and Sosa Hills, near La Boca, running directly out to sea, and placing their tidal locks at Sosa.

Senator KITTREDGE. No; at Miraflores, is it not?

Mr. STEVENS. At Sosa.

Senator KITTREDGE. In the majority report?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. Maybe I misunderstood it. I understood that their tidal lock was at Miraflores.

Mr. STEVENS. I have talked so much about locks that maybe I have got mixed up about it.

Senator KITTREDGE. I think you will find that they place their tidal lock at Miraflores.

Mr. STEVENS. I will read from page 45, paragraph 5, of the majority report:

The canal continues in a straight line through the swamps to and through the saddle between Ancon and Sosa Hills, where the tidal lock is to be placed, and thence to deep water off the Isle Flamenco. From Miraflores to the lock the canal will be leveed so as to prevent the tidal flow from entering it save through Corozal sluices.

The French plan required a tidal lock at Miraflores, some 5 miles from the bay shore, whereas in the new location it will be in the low Ancon-Sosa saddle, thus bringing it almost to the margin of the shore and avoiding the long approach channel wherein tidal currents might exist if the locks for their control were at Miraflores, far inland.

Senator MORGAN. What would be about the length of that embankment?

Mr. STEVENS. Through here [indicating on map]?

Senator MORGAN. Yes.

Mr. STEVENS. A third of a mile or a quarter of a mile.

In regard to the last part of that quotation, it is held by some authorities that in a narrow channel, such as we would have here, comparatively narrow, that the difference between high and low tide is so great, being 23 feet at extreme tide, that the incoming tide would produce current, making it difficult to navigate. That is purely theoretical.

Senator KITTREDGE. That is the reason they put the tidal lock there?

Mr. STEVENS. Yes.

Senator KITTREDGE. At Sosa, instead of at Miraflores?

Mr. STEVENS. Yes, sir. I should be inclined to doubt it, but my opinion probably is not of great value on that point.

I had borings made probably every thousand feet, straight through this line, and a lot of borings all through here [indicating on map], and at this point here, where you see these fine lines [indicating], there is quite a rise of ground; I think the summit is 40 to 50 feet above the general surface of the swamp. That is rock, and there would be heavy rock cutting through there, where they propose to go. On account of the location of the rock at that point, they put in their overflow works, their regulation works, there, that were supposed to take about one-third of the overflow that comes from the Gamboa dam. Instead of letting it all go that way [indicating on map], they let part of it through here [indicating] by these artificial regulation works.

Senator MORGAN. If the gentlemen are through asking specific questions, I should like to put a general question to you. If you build a lock canal at an elevation of 85 feet, with a safe dam at Gatun, safe locks at the same location, and safe locks all the way through to the Panama Bay; and if, on the other hand, you build the canal recommended by the majority, a sea-level canal, with safe sea-gates at Sosa, so that either canal should be made in the best way in which it can be made—shipowners and insurance officers are deeply interested in the safety of the navigation of a ship in the sea-level canal, for instance, as compared with the lock canal which I have just been trying to describe—what dangers are to be apprehended, reasonably, in the navigation of the lock canal, that are greater in such a case, as I supposed, than the dangers of navigating a sea-level canal of the same sort?

Mr. STEVENS. I suppose there is no doubt but what there is always danger in passing a ship through a lock, and the greater the number of the locks the more danger there is. That would be the disadvantage, if it could be so called, of the lock canal. With a sea-level canal I should imagine the greatest danger would exist in the comparatively narrow crooked channel, the danger of meeting passing ships, and the danger of grounding, and the danger of heavy masses like an 18,000-ton or a 20,000-ton ship running into the wall. Even at very slow speed such a vessel would have a tremendous momentum.

Senator MORGAN. Comparing the two together, which do you think would be the least dangerous for ships?

Mr. STEVENS. As you have discovered, my faith is pinned to a lock canal. Therefore I would think the lock canal would be the safer.

Senator MORGAN. That is your opinion?

Mr. STEVENS. That is my opinion; yes.

Senator MORGAN. Your opinion is that of the two canals proposed, both of them constructed as perfectly as art can provide, the danger of the navigation of a sea-level canal is greater than that of a lock canal?

Mr. STEVENS. A sea-level canal constructed of the dimensions that are proposed here?

Senator MORGAN. That is what I mean. I mean the propositions that are before the committee.

Mr. STEVENS. Yes, sir. There is no doubt in the wide world that if you had a very wide canal, say 1,000 feet all the way through, at sea level—in other words, what has been called a strait—that would be ideal. There is no reason to believe, however, that it would not be beyond the finances of even the United States.

Senator MORGAN. And even that great broad strait that Mr. Bunau-Varilla speaks of might not let enough water through from the Pacific Ocean to submerge the islands in the Caribbean Sea?

Mr. STEVENS. I do not think it would do that; no, sir.

Senator MORGAN. You think not?

Mr. STEVENS. That is all theory, you know. I could not say.

Senator HOPKINS. You have said that you prefer the lock canal. I wish you would give in detail your reasons for that opinion, regardless of anything in either the majority or the minority report.

Senator MORGAN. Has he not already given them in detail?

Mr. STEVENS. I will give them very quickly, in general: I think for a less price you are getting a superior article.

Senator HOPKINS. What do you mean by a superior article?

Mr. STEVENS. A better canal.

Senator HOPKINS. In what respects is it better?

Mr. STEVENS. In respect to time of navigation; in respect to safety; in respect to the ease with which in the future, if you require it, it can be so quickly and cheaply enlarged. To illustrate: Supposing that the canal was built, as I notice the minority board have reported in favor of, 45 feet throughout, excepting in the locks, where it would be 40 feet. I presume the extra 5 feet is to avoid dredging continually. Suppose it should be decided that 45 feet or 40 feet, as the case may be, did not provide water enough. What would be the process? We have a dam built that practically is strong enough to carry water clear to the top of it without any danger whatever.

All you have to do to deepen 36 miles of that canal is simply to raise the bottom of your sluice gates 5 feet. You have deepened the entire lake, and consequently the canal, for 36 miles, without any dredging or other work than leveling to get the 50 feet through. It is only necessary to dredge the two approaches, the sea-level approaches, about 12 miles.

Senator GORMAN. You would raise your locks?

Mr. STEVENS. Yes; you would have to rebuild your locks. The locks would undoubtedly have to be rebuilt anyway when that time came.

Senator KITTREDGE. Why would they have to be rebuilt anyway?

Mr. STEVENS. If you needed a larger capacity than they have recommended, 95 by 900 feet.

Senator KITTREDGE. Is there anything in the construction of them that would require rebuilding?

Mr. STEVENS. Oh, no; not until their capacity got to be too small.

Senator GORMAN. If you increase the depth of water, you would have to increase the height of your lock?

Mr. STEVENS. A little; yes, sir. What they really would do instead of rebuilding the existing locks would be to build new locks alongside—of larger dimensions.

Senator DRYDEN. Let me repeat the question which I put to you some time ago: Eliminating the element of danger which you have referred to just now, what would be the relative advantages to commerce and to the Government in respect to its vessels, as to expense and time, of these two systems, for the boats passing through this canal?

Mr. STEVENS. The comparison as to time, Senator, is hard to demonstrate. I think the two reports have gone into that more or less. I am not a sailor or a ship captain, and of course all my ideas are gotten from observation and not by actual experience. But we do know this: That in the Soo Canal, which is the longest example of a canal in the world—something like 90 miles, I believe—no two ships are allowed to pass at speed. They have passing points established here and there, where they have to drop in to one side, and are side-tracked. That is done whenever two ships meet. They have both to come down to a very slow speed, and one of them has to be tied up at the shore, and to lie there until the other ship has passed, just as is done when two trains pass each other on a single-track railway.

That same condition of operation would undoubtedly obtain in the Panama Canal on the sea-level proposition, with the widths indicated here. In other words, it would be absolutely unsafe for two ships to pass otherwise, with a width of 150 feet, which you must figure as the width at the bottom.

Senator MORGAN. Both of them being in motion?

Mr. STEVENS. Both of them being in motion; and you would have to have these passing places rigged up with small docks, with snubbing posts, and one of the ships would absolutely have to tie up in order to be safe. A ship might go through and meet with no other ship, or it might meet six or eight. You can not tell anything about that. Whenever they met there would be that delay. In addition to that, with a narrow channel and a comparatively crooked channel, their speed must be slow. I do not think any of us comprehends the

tremendous impact of one of these big vessels weighing so many thousand tons, even when it is moving only a mile an hour, if it strikes any obstacle. And the larger the ships the greater the danger.

In other words, with one of these large ships, if the pilot lost control of her for an instant, she would go slap against the side of the canal, whether it was a sea-level canal or any other kind of a canal; and the narrower that channel is the greater is the danger. Then, too, the danger with a sea-level canal at that depth, and with a narrow channel, is that at a number of points there are small streams coming in from this diversion channel. With that cut through there, 40 feet below the level, it is the lowest point in the country, and everything must drain into it. It is the sewer of the country. These small streams will be bound to bring in more or less mud, and will form little bars.

When you take water that carries an amount of soil—in other words, muddy water, depending on the velocity and the saturation, or the amount of soil in the water—the water carries this detritus along, and whenever that water stops dead slow, there is only one thing for the sediment to do, and that is to deposit; and it deposits more or less all the time, in proportion to the velocity of the current. That is what has caused the estuary of the Mississippi and these other rivers, and that is what has caused the bar at the mouth of the Mississippi. There are numberless little streams of this kind that will come into the canal at all points along the line, with the narrow restricted channel of 200 feet, or 150 feet, for miles, in my opinion, and there will constantly be danger of these little points, that the utmost vigilance could not protect. They would have to be continually cleaned out. Sooner or later ships would go aground, which, of course, would be disastrous.

Senator MORGAN. Anticipating that Congress may come to the conclusion, corresponding to the recommendations of Professor Morrison, first, that Bohio is the key of the lock canal in the Isthmus, and, secondly, that it is practicable to build an earthen dam with a stone core at Bohio, and in order to meet that view of the subject (which it is entirely possible, if not probable, will be presented to Congress) I wish to ask you whether you have made examinations of the borings that have been made at Bohio?

Mr. STEVENS. Yes, sir; I have looked into them.

Senator MORGAN. Are the conditions there such as that you would advise the building of an earth dam, say, on the same principles that the minority of the committee advise the building of an earth dam at Gatun? Do you think an earth dam could be as safely built at Bohio as it could be at Gatun?

Mr. STEVENS. I do not; no, sir.

Senator MORGAN. In order to build a dam at Bohio of that character, would it be necessary to excavate below 128 feet, where the Isthmian Canal Commission of 1901 found boulders that they mistook for solid bottom? Would it be necessary to go below that? If I understood Mr. Wallace's statement correctly, having bored through these boulders, he found rotted wood and other material there of a character that would bear water, down to within a foot, or such a matter, of the bottom of the geological gulch. Would it not be necessary, with the statements that have been made by Mr. Wallace, or the

explorations that have been made by him, to take out all that material down to the bottom of that gulch, and replace it with other material?

Mr. STEVENS. Well, the material at Bohio, as demonstrated by these later borings—Mr. Wallace made all the borings—showed that instead of boulders they had solid rock. Then they went, instead of 128 feet, to a depth of 163 feet before they struck what they finally decided was solid rock. At different distances down from the surface all the way across they got a great deal of coarse gravel, water-bearing strata, without any clay at all, possibly 30 or 40 feet in thickness. Undoubtedly water will flow through that subterranean strata.

Senator MORGAN. They found wood under there, too, did they not?

Mr. STEVENS. I do not recall the wood.

Senator MORGAN. That is a fact.

Mr. STEVENS. That has escaped my memory, if I ever knew it.

As far as going down to the bottom and taking out and replacing that is concerned, that is a question that engineers are very strongly divided on. George Morrison—I presume you mean Professor Morrison?

Senator MORGAN. Yes.

Mr. STEVENS. I think his opinion was that the underflow there could be neglected.

Senator MORGAN. Yes.

Mr. STEVENS. That it would be safe to build a dam without going down there, I would not care to say. I should feel much safer if that underflow was cut off, if I were going to build a dam there.

Senator KITTREDGE. Where does that underflow go to after it passes Bohio?

Mr. STEVENS. It comes out again below, in the river.

Senator KITTREDGE. Whereabouts?

Mr. STEVENS. Nobody knows. You know that the Missouri River above South Dakota, away up there, carries more water than it does below.

Senator KITTREDGE. Yes.

Senator MORGAN. You found in the borings at Gatun, or the explorations that were made there, that in consequence of the slowing down of the currents coming down this geological gulch the heavier materials, such as boulders and coarse gravel and the like, had been deposited above Gatun, and that there this finer material, the sand, etc., and clay, had been deposited on the bottom, or near the bottom, at Gatun?

Mr. STEVENS. We found that difference in the material, and the only explanation that seemed reasonable to me is that one.

Senator MORGAN. Does not the building of an earth dam to hold back a great volume of water depend upon the compactness of the material at the bottom of that dam more than upon the compactness of the material up higher on the dam?

Mr. STEVENS. Why, of course the water has more effect in filtration through where the pressure is the greatest. Consequently the bottom should be more compact.

Senator MORGAN. So you found the advantage in favor of Gatun that was missing at Bohio?

Mr. STEVENS. Yes, sir.

Senator MORGAN. That is the situation?

Mr. STEVENS. Yes, sir.

Senator MORGAN. To say nothing of the wood, if the wood was there?

Mr. STEVENS. Yes.

Senator MORGAN. In what way was it that the Isthmian Canal Commission happened to make this mistake or oversight about having gone to the bottom in those borings?

Mr. STEVENS. I do not know, Senator. It was before my time, you know.

Senator MORGAN. Suppose they had not used diamond drills, would they be likely to cut through the bowlders and get to the bottom?

Mr. STEVENS. I think the diamond drill, bringing up a core, is the only reasonable way.

Senator MORGAN. They all said that they did not use diamond drills, but used what I call churn drills, although I do not know that I am correct about that. I will get you to describe to the committee, if you please, one of these water drills, or churn drills, and then the diamond drill, as to the manner of handling them, and the effect of them.

Mr. STEVENS. The ordinary water drill means simply a pipe, 2 inches in diameter, for the sake of illustration, that is driven down. Then a jet of water is pumped down or forced into that, and that loosens the material up. Then you place inside of that, to carry your water jet down, a smaller pipe. As the water loosens up the material in the larger pipe it is forced up through the annular space between the two pipes, and the smaller pipe gradually goes on down and you keep on driving the larger pipe down.

Senator MORGAN. In that way artesian wells are driven?

Mr. STEVENS. Yes. A diamond drill is a drill that is run by machinery and that goes down with an auger, you might call it, with the cutting surface formed of black carbon, called diamond, and that forces a core, cuts an annular section, and forces the inside right up, so that you get samples as you go down.

Senator MORGAN. You get samples at the various depths?

Mr. STEVENS. Yes, sir.

Senator MORGAN. The large bowlders would stop one of these water drills?

Mr. STEVENS. Yes, sir.

Senator MORGAN. It would not go through it?

Mr. STEVENS. No, sir. Of course if you made a careful examination you would go off a little distance and try again somewhere else.

Senator MORGAN. So that the real occasion of the mistake was the fact that they used water drills on the Bohio site instead of diamond drills?

Mr. STEVENS. Or else they did not drill holes enough. I could not say. If they had found a bowlder and they had gone off and drilled three or four more holes in different places they would have gotten by it.

Senator MORGAN. Your opinion is, then, that a dirt dam would be very difficult to construct, and not entirely reliable after it was built, if it was located at Bohio?

Mr. STEVENS. I do not know as the difficulty of construction would vary any at either place, but I feel this way, that I would not condemn an earth dam at Bohio, neither would I say that it is perfectly

safe. I would say that I would feel rather dubious as to the outcome, not because I think the dam would go out, but I would think, owing to this gravel—this percolating material below it—that you might lose a great deal of your water there.

Senator MORGAN. Some question has been alluded to, rather than stated precisely, in the majority report, and I believe also in the minority report, in regard to the preservation of a canal against efforts to destroy it with dynamite or any kind of explosives. Which of these canals would you think would be most liable to a successful assault in that direction?

Mr. STEVENS. You have brought up a point that I have given some thought to. Not being a military man, I do not suppose I am competent to express an opinion, but if you will allow me to wander on in my own way, I will give you my idea of it.

Senator MORGAN. That is what I want you to do.

Mr. STEVENS. I did not—and I use the word “did” advisedly—in my own mind favor putting any locks near the sea or any artificial works whatever. The plan that I carried in my mind when I said that I made an estimate of \$150,000,000 did not contemplate any dams at Sosa or any artificial works at all. I proposed about the same elevation—I think I said 80 feet—for the high-level canal, as is proposed in the minority report, and I proposed putting my entire lockage system at the south at Pedro Miguel and Miraflores there together, with this idea in view: That the locks at that point will be from $8\frac{1}{2}$ to 9 miles—we will say 8 miles—in a straight line from the nearest point where a ship can lie, providing she reduced the fortifications in the outer harbor. In other words, she would come up to the mouth of the canal and could lie there, but she would have to throw a shell 8 or 9 miles before she could strike anything that she could damage.

The same condition prevails exactly on the north end, with the dams at Gatun. It is about 8 or 9 miles to where a hostile ship could lie, unless she came directly into the canal. She would not have anything to shoot at. My notion is that, with a small object like a lock lying at an unknown point—unless the enemy had absolutely correct charts—a ship would have pretty hard work to do any damage at that distance.

Then, my idea at the south end of not creating that lake was one that was touched upon this morning, not to make an artificial freshwater lake right at the doors of Panama on account of mosquitoes and fever breeding.

Senator HOPKINS. How would you get from the sea up to Miraflores?

Mr. STEVENS. By dredging a channel; bringing the sea level to Miraflores, just the same as the minority proposes to bring it, at the other end, to Gatun.

Senator KITTREDGE. They are agreed, substantially, up to Gatun, are they not?

Mr. STEVENS. Yes, sir.

Senator HOPKINS. You would make your rise of 85 feet instead of 30 there?

Mr. STEVENS. Yes; I would make my entire rise there.

Senator MORGAN. We have been speaking of an enemy who might invade from the outside with ships. Suppose Panama should get at

war with the United States, which she has a perfect right to do, if she wants to, what protection could we possibly have against their dynamiting our ships in that Culebra cut?

Mr. STEVENS. You would not have any, unless you policed it there so thoroughly that they could not get in there.

Senator MORGAN. There is nothing else that would prevent it, except the absolute power and control over it in a military sense?

Mr. STEVENS. That is my opinion exactly.

To go on a little further about the way these two canals could be destroyed in case of war, of course, given a sufficient amount of high explosives and time and a few determined men, you can blow locks so as to ruin them. So you can the Gamboa dam; so you can the spillways. I can go to several places on any canal, a sea-level canal particularly, because it is deeper, and the slopes are very much higher, with a few thousand pounds of high explosives and a few determined men to help me, and I can place any canal there out of service in a very short time. I would simply put that high explosive against the face of those bluffs and touch it off and go away. I could shoot hundreds of thousands of pounds right in there where there are no artificial works at all, simply the slopes of the mountain.

Senator MORGAN. That means that if Panama should be at war with the United States, we would be absolutely in her power?

Mr. STEVENS. We would have to protect our canal; there is no question about that.

My reason for being in favor of putting these artificial works inland I have explained. It seemed clear to me that that was the safest way. In other words, if a man goes out in a blizzard his hands are safer in his pockets than they are outside.

Senator MORGAN. That brings me back to my original proposition, Senator Dryden.

Senator DRYDEN. I have always had a pretty strong leaning to that proposition.

Mr. STEVENS. I have ascertained that the minority figures—I merely give this as hearsay, although I have no doubt that it is correct—the figures which they have made and their analysis show that the proposition to put the locks at Sosa and the dam there is some \$6,000,000 cheaper than the proposition to put the locks inland. Six million dollars is a good deal of money, and I do not know whether the military or sanitary necessities would justify the expenditure at Panama of that sum.

Senator DRYDEN. Have you made a calculation of the cost and the length of time that it would take to construct a sea-level canal?

Mr. STEVENS. No, sir; I have not.

Senator DRYDEN. I have not read the majority report, and therefore I do not know whether they stated an estimate.

Mr. STEVENS. I think they say about fifteen years.

Senator DRYDEN. And at what cost?

Senator KITTREDGE. Twelve or thirteen years, they say.

Mr. STEVENS. Yes.

Senator SIMMONS. Do they make any estimate of the cost?

Mr. STEVENS. Two hundred and forty-seven million dollars.

Senator KITTREDGE. Do you prefer a lock canal with an elevation of 85 feet to a lock canal with an elevation of 60 feet?

Mr. STEVENS. Why, as between the difference in cost, as I recall it—I can not give you that cost now—I prefer the 85 feet.

Senator KITTREDGE. Why?

Mr. STEVENS. Simply because you have got so much more deep, wide navigation that your canal can be navigated a little quicker on that account, and that it can be so readily enlarged.

Senator KITTREDGE. Why not increase the elevation?

Mr. STEVENS. Above 60 feet?

Senator KITTREDGE. Above 85.

Mr. STEVENS. Well, of course there is a limit that you do not care to go above in anything. I would be in favor of any lock canal rather than a sea-level canal, to be frank with you. I do not mean that I would go up to 150 feet or 200 feet, but I mean any elevation up practically to 85 or 90 feet.

Senator HOPKINS. The 85-foot elevation that you have is one protection against the overflow of the river there, is it not, at Gamboa?

Mr. STEVENS. Yes, sir. Of course with anything below 80 or 85 feet the problem of the regulation of the overflow from the Chagres has got to be met again—

Senator HOPKINS. Yes.

Mr. STEVENS (continuing). By dams at Gamboa. Going up to 80 or 85 feet you, in my opinion, eliminate that and settle what is the great engineering proposition. That is the reason for going to that elevation.

Senator HOPKINS. But at 60 feet you would not eliminate that?

Mr. STEVENS. At that height it would be necessary to build the Gamboa dam, in my opinion.

Senator HOPKINS. That was the impression that I gathered from your discussion of that matter before the recess.

Mr. STEVENS. You see, with the elevation of 60 feet you would only throw 10 feet of water through the Gamboa gap.

Senator HOPKINS. Yes.

Mr. STEVENS. In other words, that would be very near the edge of the dead water, and then, undoubtedly, these heavy currents coming down there would make navigation—well, it might not destroy it, but it would make navigation through that section of the canal difficult while they were coming in.

Senator HOPKINS. Yes.

Mr. STEVENS. I regard the solution of the engineering difficulties in building the Panama Canal to be the control of the Chagres River.

Senator HOPKINS. Yes.

Mr. STEVENS. There are grave questions to be met, of course.

Senator HOPKINS. But that is the question?

Mr. STEVENS. To my mind, yes.

Senator HOPKINS. And the most feasible way of doing that is by the lock canal with an 85-foot elevation?

Mr. STEVENS. That is my candid belief.

The first time I went over the canal, you might say—the second time I ever went across the Isthmus—of course I had in mind the proposition that had been advanced, largely by the old Commission of 1901 and 1902. I could see the force of the argument very readily about taking care of the Chagres River. I had understood from various writings that Bohio was the lowest point in the valley where

the dam could be built. The first thing that occurred to me was: Is it a fact or is it an assumption? And going down through there I noted the narrowness down here at Gatun. I immediately asked some of my assistants why they selected Bohio instead of Gamboa. They said the dam at Bohio was better than at Gatun. I found that there were no borings there, and that they did not know anything about it. I commenced to get ready to find out. About that time there came a request of the consulting board, which convened here the 1st of September. They cabled down instructions to go on with borings at Gatun—just what I was preparing to do—with the result that we have explained, that in the opinion of everyone, I think, Gatun proved to be the better site.

Senator KITTREDGE. What about the comparative expense of maintenance and operation?

Mr. STEVENS. That is gone into very thoroughly in the report. You can get a better idea from the report about that than I can give you.

Senator KITTREDGE. A comparison has been made in the majority report on the basis of a lock canal with 60-foot elevation.

Mr. STEVENS. Yes.

Senator KITTREDGE. But not with a canal with an elevation of 85 feet.

Mr. STEVENS. There would be very little difference. There are one or two discrepancies, however, in the majority report which I can not quite reconcile, which must be taken into consideration. You have got to consider the cost of operation—that is, your maintenance, your men to handle your points where ships pass, and your lighting and policing and everything, to which has to be added the interest on the cost of that canal. Now, \$100,000,000—\$107,000,000 on the face of the report—is the difference in cost, which, at 2 per cent, is something over \$2,000,000. That must be added to the maintenance of a sea-level canal as compared with the other, which I do not think their report brings out.

Senator MORGAN. Two million dollars a year?

Mr. STEVENS. Two million dollars a year. That is in addition to the fixed charge. Now, frankly, I do not believe that the sea-level estimate is correct, for several reasons. In the first place, while I am chief engineer of the Commission, I never yet have satisfied my own mind, or become satisfied as to what it is going to cost, even approximately, to take out the lower 40 feet of that canal through Culebra Cut.

Senator KITTREDGE. You are not talking of maintenance?

Mr. STEVENS. I am talking about construction.

Senator KITTREDGE. I was asking you about maintenance and operation.

Senator HOPKINS. Let him finish on this point.

Mr. STEVENS. This bears directly on maintenance and cost of operation, because it is the cause of some of these fixed charges. The Board reported that the cost of taking out the material from plus 10, which is 10 feet above the sea level, down to minus 40, which is 50 feet (40 feet of which, as this profile shows, and as we all know, is rock), \$1.25 a yard. Well, I do not know anywhere in the world where rock has been ever taken out under just those conditions—in

other words, under as hard conditions as these would be. I have not studied up any plan yet whereby, either as engineer or contractor, I would start to take it out. Of course it is possible that that estimate may be correct.

Senator KITTREDGE. That bears upon what you regard as an erroneous conclusion?

Mr. STEVENS. An erroneous estimate.

Senator KITTREDGE. An erroneous estimate of the majority of the Board, or the Board of Consulting Engineers, concerning the cost of construction?

Mr. STEVENS. I do not think the conclusion they have reached is justified.

Senator KITTREDGE. I understand.

Mr. STEVENS. In other words, shortly speaking, to my mind that prism below plus 10 particularly, or particularly below the sea level, might just as readily cost \$2.50 a yard as \$1.25 a yard, and as it amounts to 17,000,000 feet the total would be something like \$23,000,000 to be added to the cost of the sea-level canal.

Senator KITTREDGE. In that regard you differ with the Board of Consulting Engineers concerning the cost of construction?

Mr. STEVENS. I do not say that they possibly may not be right. Some way may be found to take it out for that money.

Senator KITTREDGE. I was asking you about the difference in cost of maintenance and operation between a lock canal and a sea-level canal.

Mr. STEVENS. Exactly. And assuming that that addition was made to the cost of the sea-level canal, it means that the fixed charges of the sea-level canal would be much more than estimated here.

Senator KITTREDGE. I am leaving out of consideration at present the question of fixed charges—that is, the difference in cost of construction.

Mr. STEVENS. Yes.

Senator KITTREDGE. Suppose that they were the same; compare the difference in the cost of operation.

Mr. STEVENS. I think there would be very little difference in the cost of operation. On the one hand, you would have your locks to handle vessels through, and you would have the maintenance of your power plant. Your lighting would be practically the same, comparing one canal with the other. In the case of the sea-level canal you would have the different passing points along the line, with men stationed there to handle the ships, to see that they obey the rules, and so on. In either case you would have trained crews and pilots to take the ships through the canal. I can not see that there would be a great difference in the cost of operation.

Senator HOPKINS. Aside from the fixed charges?

Mr. STEVENS. Aside from the fixed charges. My idea is that the sea-level canal would be more costly to maintain, because, as I have explained, on account of these smaller streams coming in it would be necessary to maintain a number of dredges continually to keep the channel at a proper depth and width. It might not be necessary, but there is a contingency that must be contemplated.

Both boards have gone into the question more thoroughly, of course, than I could. I have no disposition to dispute their figures.

Senator MORGAN. Mr. Stevens, is it to the advantage or disadvantage of that canal work that the eight-hour law should apply to it?

Mr. STEVENS. I am in favor of working more than eight hours. Yes; for the reason that I think we can do the work quicker and cheaper.

Senator MORGAN. Is it necessary, in your opinion, in order to make proper progress with that work that we should have access to any place in the world where good labor can be obtained, as, for instance, China?

Mr. STEVENS. Decidedly, in my opinion.

Senator MORGAN. Yes. You think we are doing the Government an injustice in excluding ourselves from the opportunities of employing Chinese workmen there?

Mr. STEVENS. I think so. I mentioned what is, in my opinion, the greatest engineering feature in regard to the construction of the canal, the control of the Chagres River. That is purely from an engineering standpoint. Now, the greatest business difficulty, if I may call it such, the greatest practical difficulty, outside of the engineering features, is the question of labor.

I do not think that I can say, or anybody can say, that Chinese labor is the best and that ours is the worst. I do say that there is better labor than the labor that we are so far using. At least, I think so. I think that I should be very remiss in my duty if I did not try to get the best possible labor for the work to be done.

The CHAIRMAN. Do you think it would be quite as well for those people down there at work, both black and white, if they worked ten hours instead of eight?

Mr. STEVENS. I think so; yes, sir. I gauge everybody by myself. I work from fourteen to eighteen hours. [Laughter.]

The CHAIRMAN. But the ordinary laborer probably would not want to go beyond ten hours. You think he would be as well off if he worked ten hours as if he worked eight?

Mr. STEVENS. I think he would be as well off, if not better.

Senator MORGAN. Do you prefer the plan of paying by the hour or by the day?

Mr. STEVENS. That is something that I have not given very close attention to, Senator. There is always this ghost in the background, that if we contract for that work, as I am decidedly in favor of doing—at least asking for intelligent bids—then comes up the question as to the other fellow, who practically carries out the work, the kind of labor that he wants, and the number of hours that he wants to work, and the way he wants to pay his men.

Senator MORGAN. You would leave that to him?

Mr. STEVENS. I should leave that to him, with authority to veto.

Senator HOPKINS. With certain limitations?

Mr. STEVENS. With certain limitations.

Senator DRYDEN. Of course, if it is done by contract, your idea is that the contractor should have the right to employ whatever labor is most advantageous, and to buy his material in any market where he can get the proper material at the lowest price?

Mr. STEVENS. I think you would get much more favorable bids if restrictions in that regard were shut off entirely.

Senator DRYDEN. There is no doubt about that.

Mr. STEVENS. No, sir.

Senator GORMAN. Mr. Stevens, I want to go back a moment to this dam. I understood you to say a moment ago that if the dam was constructed on the original plan at Bohio, if it should give way it would destroy the canal in a very short time?

Mr. STEVENS. At Gamboa.

Senator GORMAN. At Gamboa?

Mr. STEVENS. The one that shuts off the flood waters from the Chagres; yes, sir.

Senator GORMAN. That would destroy the canal?

Mr. STEVENS. It would throw it out of service until the dam could be rebuilt and the works replaced.

Senator GORMAN. What would be the effect if the dam there on the minority plan gave way?

Mr. STEVENS. The entire canal would go, 36 miles of it.

Senator GORMAN. It would?

Mr. STEVENS. Yes; the lake would disappear.

Senator DRYDEN. And if there should happen to be a vessel going through the canal at that time, it would destroy it, I suppose?

Mr. STEVENS. It would depend upon where it happened to be. It would go aground all right.

Senator GORMAN. I understood you to say that at this point here you were perfectly satisfied with the construction of an earthen dam?

Mr. STEVENS. Yes, sir.

Senator GORMAN. Without a masonry core, as I understood you?

Mr. STEVENS. Yes, sir.

Senator GORMAN. What is that based on—experience anywhere else in the world with such a dam under similar conditions or nearly similar conditions?

Mr. STEVENS. There are similar dams that the reports here call attention to that carry larger heads of water. I understand that there is one in Baltimore. I never have seen it and do not know anything about it. There are several irrigation dams in the West, in California and that country, that the report calls attention to, that are much higher and carry larger bodies of water. My deductions are drawn largely from the way such a dam would look if it was built; I do not think anybody comprehends what it means. It means a range of hills or a hill similar to the hill between two water courses. I can not imagine any possibility by which such a dam could be destroyed.

Senator GORMAN. In view of the fact that Mr. Linden Bates and Major Gillette both condemned that character of dam, and then that this board of foreign engineers, summoned by the President, and some of the American engineers—I have forgotten who they are; I do not find their names here——

Senator KITTREDGE. General Davis, Mr. Parsons, and Mr. Burr joined them.

Senator GORMAN. In discussing that question, and discussing the possibilities of giving way, they came to the conclusion, as they stated, that the importance of the work is so great that they would not risk a dam to control this river unless it was a masonry dam. In view of that fact, do you think it would be safe and wise for the Government to undertake an experiment of that sort without further and more careful examination?

Mr. STEVENS. Careful examination of what?

Senator GORMAN. Of the possibilities of its standing. Would you, in other words, in view of the dissent of all these very able men, agree with the minority of this engineer commission and in your own view undertake it?

Mr. STEVENS. Yes, sir.

Senator GORMAN. Only because of the difference in the cost?

Mr. STEVENS. No, sir; because I feel that a dam built in that way would be absolutely secure. There will be no question about it. Of course all of these propositions are merely men's opinions.

Senator GORMAN. That is true; but you would not hesitate to recommend it notwithstanding this dissent?

Mr. STEVENS. No, sir.

Senator GORMAN. Do you not think that a masonry dam there would be more secure, or one with a core of masonry through the center of the dam?

Mr. STEVENS. I do not see where it would add anything at all to the strength or safety of it. It seems to me when you get a thing that you feel in your own mind to be absolutely safe, when you have not a shadow of a doubt about it, that any additions you put on it are superfluous.

Senator GORMAN. Yes, if it is absolutely safe. Here I suggest that that is a very positive opinion or conviction that you have.

Mr. STEVENS. Well, I am a positive man.

Senator GORMAN. So I observe. That is the kind of man we want, I think.

Mr. STEVENS. There is no possibility of the water ever going over it.

Senator GORMAN. No.

Mr. STEVENS. There is no possibility of the water pushing it away.

Senator GORMAN. Or getting in it?

Mr. STEVENS. No, sir; and I do not see how anybody could go there and dig it away. When you come to think of it, you have to tunnel practically 375 feet, even at the top, to get a hole through it. Even in time of war you would have to lose control of that canal for a very long time to enable anybody to do that. The animals can not burrow through it, and the material will be of such a nature that the water can not percolate through it. I can not conceive how it can go.

Senator HOPKINS. At its base it is how wide?

Mr. STEVENS. Twenty-seven hundred feet.

Senator HOPKINS. In other words, you construct a mountain there?

Mr. STEVENS. That is it.

Senator MORGAN. You employ a great deal of cement in making the central works and the regulating works of the dam at Gatun?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Is there any arrangement made by which this cement is to be inspected?

Mr. STEVENS. Oh, yes, sir; yes, sir. I test every invoice of cement we get. Every few sacks or barrels we make a thorough test.

Senator MORGAN. You test it in regard to the time of its hardening?

Mr. STEVENS. Yes, sir; and its strength after it is hardened.

Senator MORGAN. And the tensile strength?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And the breaking strain?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And so on?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And so, when you make up your test, you feel absolutely certain that there is to be no trouble about the perishing or giving way of the cement?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Does that make a stronger wall mixed with stone than a cut-stone wall?

Mr. STEVENS. A stronger wall?

Senator MORGAN. Yes.

Mr. STEVENS. I think it does, when it is well made.

Senator MORGAN. For the reason that it is continuous and has no joints in it?

Mr. STEVENS. Yes, sir. Of course in regard to the question of concrete, which is the one we have under discussion, the use of it is trebling almost every year. The French for a great many years have used concrete in very much larger proportions than any other engineers or any other constructors in the world; and only within the last ten or fifteen years has its use extended very largely here. In fact, they are building almost everything of concrete there. The largest single structure I ever built was the lining of a tunnel, that was complete, without a joint, from one end to the other, nearly 3 miles long—something over, as I recall it, 100,000 yards.

Senator GORMAN. Was that a railroad tunnel?

Mr. STEVENS. Yes, sir.

Senator MORGAN. I would like to say to the chairman of the committee, to venture an opinion—though I am not in any sense a scientific man and do not know anything about chemistry or anything of that sort—that Alabama can furnish to that canal, at a dollar a barrel, as good cement as you can make in France or Germany or elsewhere.

Mr. STEVENS. Portland cement?

Senator MORGAN. Portland cement, delivered at Colon—all that is necessary to fill up the canal, or ten times over.

Senator HOPKINS. I think it is regarded among engineers that the American Portland cement is the best quality, is as good as you can get abroad. Is not that correct?

Mr. STEVENS. Without doubt.

Senator HOPKINS. That has been my understanding for a number of years.

Mr. STEVENS. On this particular job that I speak of, I used largely foreign cement, because it came at a very low rate around the Horn. This was on the west coast of the State of Washington. But I recollect that at one time one of the ships got into distress around the Horn and put in at Valparaiso. The Lloyds made a survey of it, and they reported part of the cargo damaged. They were going to scale it to us. I said: "No; if part of the cargo is damaged, the chances are that the balance is, and I won't have it at all." That made me run short of cement, and I bought American cement in the East and took it across the continent; and in that way, as a result of the tests that I made then, I would prefer our American cement, although the cement we generally get are blended cements.

Senator DRYDEN. Does not the foreign cement lose part of its strength through dampness in being brought across?

Mr. STEVENS. No; I do not think the short time it is en route makes any difference.

Senator GORMAN. Mr. Stevens, if we adopt the minority plan for this dam below here, how much is it going to increase the length of your haul for the average material from the great divide? It makes a very much longer haul necessary there, does it not?

Mr. STEVENS. Do you mean the waste?

Senator GORMAN. Yes; the waste.

Mr. STEVENS. You will get the best dumping grounds for waste that I have found so far right in here below Bohio, right in this section here; and that haul is about the same as it would be if you hauled from the Culebra cut either to the Bohio dam or dumped in here. The length of your haul, of course, would be over this piece of track to Gatun. Let us get it exactly. I have had so many figures in my head that I can not remember them all. Gatun is 8 miles, and Bohio 17. It would increase your haul 9 miles.

Senator GORMAN. Nine miles of increase?

Mr. STEVENS. Yes. Of course you would not haul all of that. The majority of the material in here would come from the dredging.

Senator GORMAN. I see. Then you would find plenty of dumping ground for the balance in here?

Mr. STEVENS. Oh, yes, sir. You can find all the dumping grounds required here outside.

Senator GORMAN. This plan of the minority means a change of the location of your railroad through from ocean to ocean of 30 miles, does it not?

Mr. STEVENS. Yes, sir.

Senator GORMAN. And that means, of course, that the Canal Commission must pay for the reconstruction of the main line of the road?

Mr. STEVENS. Yes, sir.

Senator GORMAN. That is a part of the expense of the canal?

Mr. STEVENS. Yes, sir. That is estimated in the total cost.

Senator GORMAN. In the minority report?

Mr. STEVENS. Yes, sir.

Senator GORMAN. Well, do you get as favorable grades in reconstructing the road as you have now?

Mr. STEVENS. I think the amount they have estimated would give just as good a road as they have now; but I question whether or not I would spend money enough to build a first-class road after the canal is constructed. I think the Panama Railroad will be of very little value after the canal is built.

Senator GORMAN. You think it will not require it?

Mr. STEVENS. I should say, "No."

Senator GORMAN. In building a new road, can you buy the ties there now? Can you get them there?

Mr. STEVENS. Not adjacent to the canal. Those would probably be brought from farther down the coast, from the San Blas country or possibly from Colombia.

Senator GORMAN. That is the only material you have found that will stand that climate for any reasonable length of time?

Mr. STEVENS. Yes, sir. I think the cost now would be about \$2 a tie.

Senator GORMAN. You have brought a great many from Oregon, have you not?

Mr. STEVENS. I do not think we have brought any ties from Oregon. Last year, I think, all the supplies came from the Gulf coast.

Senator GORMAN. I have heard an intimation that they lasted just long enough to get them in.

Mr. STEVENS. I think all the ties that the Americans put in are there yet.

Senator GORMAN. Are they?

Mr. STEVENS. You will understand that they are largely for work tracks.

Senator GORMAN. Yes; I understand.

Mr. STEVENS. Now, any tie that you can use in a work track, around steam-shovel work, particularly, will never last long enough to rot. It will be cut to pieces by the continual changing, by the spiking. So it will be a waste of money to buy a high-priced tie.

Senator GORMAN. Only for the main line?

Mr. STEVENS. Only for the main line. And until the type of the canal is decided, and we know exactly how much the main line will have to be changed in the next five or six years, it will be a waste of money to put expensive ties in there, when you can get a cheaper tie that will last four or five years.

Senator GORMAN. Now, Mr. Stevens, I am very much gratified with one of your statements—that when this matter of the type of the canal is decided upon, then and not until then can you commence the work of digging it on a regular system. Do I understand you to say that?

Mr. STEVENS. No, sir; I did not mean to say that. I will commence on a regular system as soon as I get my equipment.

Senator GORMAN. And before you decide upon the type of the canal?

Mr. STEVENS. Oh, yes; I would not let that stop me. I would go on and take out material as fast as I could when I had something to do it with.

Senator GORMAN. But it will be impossible for you to attempt to contract, as I understand it, until the type of the canal is determined?

Mr. STEVENS. Why, I think so; yes, sir. It looks to me that way.

Senator GORMAN. And therefore your suggestion is that that question ought to be determined at the earliest possible moment?

Mr. STEVENS. Undoubtedly.

Senator GORMAN. When that has been determined, I understand you to say that you recommend contracting for most of this work?

Mr. STEVENS. Yes, sir.

Senator GORMAN. Do you mean by that only removing the material and getting the prism of the canal in shape, or do you mean contracting for the construction of the dam, for instance, and the locks?

Mr. STEVENS. Oh, I would separate the work in a natural division, such as would seem to be large enough to be worthy of the attention of any combination of capital or superintendency that we have in the country.

For instance, take the dredging: assuming that a lock canal is built, one division would be the dredging from the Caribbean Sea through to Gatun, which would be a very large contract. Then the

construction of the Gatun dam, then the Culebra cut—I would probably divide that in two, because the haul must go north and south—the construction of the Gatun locks, which involve something like fourteen or fifteen millions of dollars, including the excavation—that as a separate contract; possibly the construction of the other locks as a separate contract, and the other dams, etc.; and in that way you would have, perhaps, eight or ten different contracts.

Senator GORMAN. And you would divide it up in that way?

Mr. STEVENS. Yes, sir.

Senator GORMAN. And you can make your specifications, I suppose, so that there will be no trouble in getting intelligent bidders in the United States?

Mr. STEVENS. Why, I think the specifications can be made; yes, sir. It is a delicate matter to make them, one requiring a great deal of judgment; but I think we can make them.

Senator GORMAN. Suppose you were to undertake to divide the great cut in two, as an illustration, and advertise, you have the steam shovels owned by the Government and various other machinery. What would you do? Give them for the use of the contractors, or require them to buy that material?

Mr. STEVENS. It would be as broad as it is long. If you turned the plant over to the contractor, you would get a less figure in your bid. If you sold it to him, at cost we will assume, he would undoubtedly add the cost of it to his bid and increase the price enough to make it up in that way. If you let him have it on a rental, he would do the same thing.

Senator GORMAN. I assume now, that in purchasing all this equipment, which is necessarily very expensive, it was done on the theory that the Government would do the work as you are doing it down there now, by day labor?

Mr. STEVENS. No, sir. I can only answer for the equipment that I have bought. Take the sixty shovels that have been bought—forty-one of them were bought before I had any connection with the work.

Senator GORMAN. Yes.

Mr. STEVENS. I do not know what the assumption was at that time, what Mr. Wallace's or the Commission's idea was, but in my purchase of equipment I have aimed to keep this in view—to buy nothing excepting what I, as a contractor, in my best judgment, would require if I were going to do that work by contract. In other words, if a man wanted that contract I should hesitate very much in my judgment about his knowledge and ability to conduct the work unless he required that sort of equipment for that particular work.

Senator GORMAN. Precisely. So that you had in view then to dispose of it to the contractor if it were let out to contractors?

Mr. STEVENS. Certainly.

Senator GORMAN. You would not undertake to let a contractor have it for rental, as a matter of course?

Mr. STEVENS. Oh, I do not think so.

Senator GORMAN. Then, as to the removal of the material. The Government owning the railroad and the equipment, I suppose you would still have the matter of transportation under your control?

Mr. STEVENS. The transportation along the main line of the Panama Railroad must be kept in the hands of the Panama Railroad to

superintend the dispatching. I do not understand that the equipment would belong to the Panama Railroad; it would be the equipment belonging to the contractor who happens to take out that part of the cut. He could come up to the switch with his train, his equipment, and his men; there he would go under the orders of the train dispatcher of the Panama Railroad as long as he was on the rails of the Panama Railroad. He could do as he liked, as far as the Panama Railroad was concerned, once he was clear of that track.

Senator GORMAN. So that in any view the management of that road must be in the hands of the chief engineer?

Mr. STEVENS. It should be; yes, sir.

Senator GORMAN. I am very much gratified to have you make that statement.

Senator MORGAN. I just want to ask one question. Suppose you had a track laid now between Obispo and Miraflores, in the channel that you have cut out for the canal, could you run your engines through, your cars?

Mr. STEVENS. On the Panama Railroad?

Senator MORGAN. Yes.

Mr. STEVENS. Yes, sir; you could run them through, but you could not conduct your business and take out the canal at the same time.

Senator MORGAN. No, no; I am not talking about running the Panama Railroad as a commercial enterprise at all. I am speaking about the cars that would be necessary to carry off the spoil. Could you run such cars as are necessary to carry off the spoil in all the diggings between Obispo and Miraflores, for instance—can you run them in through the gap that is now cut?

Mr. STEVENS. Oh, yes, sir.

Senator MORGAN. Clear through?

Mr. STEVENS. But you understand that the canal would not be taken out in that way, by a continuous railroad through there.

Senator MORGAN. I understand that.

Mr. STEVENS. As I explained the other day, these lines must come out at separate points.

Senator MORGAN. We are speaking about transporting the spoil down to Gatun.

Mr. STEVENS. Yes, sir.

Senator MORGAN. You get that from Culebra—from those heights there?

Mr. STEVENS. Part of it; yes, sir.

Senator MORGAN. What I wanted to ascertain was whether you could, under present conditions, lay a track in there to carry that spoil down to the Panama Railroad, and on that railroad to Gatun.

Mr. STEVENS. Yes, sir; we have tracks laid down at several points where we take out spoil.

Senator MORGAN. And in the other direction, south, you could carry it to Miraflores?

Mr. STEVENS. Yes, sir; I am doing that.

Senator MORGAN. You are doing that?

Mr. STEVENS. I am doing that now, and have been for several weeks double tracking it west of Pedro Miguel.

Senator MORGAN. So that there is an open way there through which railroads can pass between Miraflores and Obispo, as you wish to carry them through?

Mr. STEVENS. Yes, sir.

Senator MORGAN. That is what I wanted to find out.

Mr. STEVENS. Of course, any railroad in the canal would be destroyed by taking out the prism, you know.

Senator MORGAN. I understand.

Senator GORMAN. Mr. Stevens, how long would it take you—of course it is largely in the nature of a guess, I know—after the type of this canal is determined upon by Congress, to prepare the specifications and advertise for bids?

Mr. STEVENS. I think the preparation of the specifications would probably require from thirty to forty days. They would be general specifications, intelligent enough so that a person could bid on them.

Senator GORMAN. A competent contractor would have a thorough opportunity to compete?

Mr. STEVENS. Well, of course they would necessarily take some time to look the ground over with the plans and specifications in their hands. That is the only way in which a man could give an intelligent bid. I would hesitate very much to accept a bid, no matter what the bond is, that was made out here somewhere in Michigan, perhaps by a man who never saw the country and knew nothing of the conditions.

Senator GORMAN. But still you think it is feasible to do that in from thirty to forty days?

Mr. STEVENS. Why, yes, sir; I think so. I think so.

The CHAIRMAN. That would not include the time of going to the Isthmus?

Mr. STEVENS. Oh, no, sir.

Senator GORMAN. Of course these contractors are enterprising fellows and pretty fair engineers. Have they been looking over the ground—any of them?

Mr. STEVENS. Not to my knowledge. They may have been. I do not know as to that.

Senator MORGAN. They have been looking it over.

Mr. STEVENS. They might have and I would not know it, you know. I do not recall anyone that has come to me asking for any data or anything of that sort.

Senator DRYDEN. Senator Morgan, is additional legislation necessary in order to put this work out by contract?

Senator MORGAN. I think a great deal of additional legislation is needed here, for the reason that we have now nothing but the will of the President in regard to anything, and have been running along in that way. I do not say that he has abused his powers or anything of the sort; but it is about time for us to come down to legislation on this subject. I think that is one of the most important steps we have to devise here—what the legislation shall be.

(The committee thereupon adjourned until to-morrow, Wednesday, January 24, 1906, at 2.30 o'clock p. m.)

SENATE COMMITTEE ON INTEROCEANIC CANALS,
Wednesday, January 24, 1906.

The committee met at 2.30 o'clock p. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Hopkins, Morgan, Gorman, and Simmons; also John F. Stevens, esq., chief engineer of the Isthmian Canal Commission.

STATEMENT OF JOHN F. STEVENS, ESQ.—Continued.

The CHAIRMAN. Mr. Stevens, I think we are ready to proceed now.

Senator MORGAN. I want to ask Mr. Stevens one preliminary question about a matter that I am not yet satisfied about: What is the width of the canal, estimated on the basis of the minority report, at Gamboa?

Mr. STEVENS. I think, Senator, that I would have to refer to the printed memorandum that I had here yesterday about that.

Senator MORGAN. Did you get that memorandum from the minority report?

Mr. STEVENS. It was made up from both reports.

Senator MORGAN. Those reports are here, and you can refer to them.

Senator DRYDEN. Your question was, Senator, as to the width of the canal at Gamboa?

Senator MORGAN. Yes.

Mr. STEVENS. My recollection is that the width of the entire water there would be something like a mile and a quarter.

Senator MORGAN. That is, between the ridges?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And there would be no particular prism of the canal in that?

Mr. STEVENS. There is a well-defined depth in the ship channel proper.

Senator MORGAN. Of how many feet?

Mr. STEVENS. My recollection is that it is 500 feet, but I am not sure.

Senator HOPKINS. Are you referring to the depth?

Senator MORGAN. A depth of 40 feet for 500 feet in width.

Mr. STEVENS. Forty-five feet. The depths in the minority report are all 45 feet, with the exception of in the locks.

Senator GORMAN. At what point is that?

Mr. STEVENS. Opposite Gamboa.

Senator HOPKINS. What is the depth there, you say?

Mr. STEVENS. Forty-five feet. I have those widths all drawn off on that sheet that I had here yesterday, as a matter of comparison. I know that it is 500 feet at that point, and it narrows to 300 feet up to Las Cascadas, where it is 200, through the deep cutting.

Senator MORGAN. Is the width of 500 feet there measured between the ridges at the level of the canal?

Mr. STEVENS. At the bottom of the canal there is a width of 500 feet, and between the bluffs—that is, the amount of dead water across there—would be about a mile and a quarter. That would be really the basin where the Gamboa gap debouches into the main valley.

Senator MORGAN. I desire to call your attention to that point, because I wish to remove any possible doubt, if there is any doubt, as to the effect of a flood in the Chagres River disturbing the navigation of a ship or disturbing the movement of the water through the canal. I will suppose that there is a flood in the Chagres River of 30 feet. That, perhaps, is not an extravagant expectation, that there will be a flood of 30 feet in the Chagres River at one time above the mean level?

Mr. STEVENS. At one period. Of course that would not be a simultaneous wall of water of 30 feet, but it might rise in a few hours 30 feet.

Senator MORGAN. That is what I mean. That body of water precipitated from the Chagres River upon the canal at Gamboa would cause, ordinarily, a great disturbance in a canal that was 150 or 200 feet wide; but in a canal that is 500 feet wide, and in an area of lake water between the ridges which you say is 2 miles wide—

Mr. STEVENS. I said a mile and a quarter.

Senator MORGAN (continuing). A mile and a quarter wide; is it your opinion that a flood of 30 feet in the Chagres River, a sudden precipitation of water, causing a flood of 30 feet in the Chagres River, would in any material sense disturb either the navigation or any of the works that might be connected with the canal at Gamboa?

Mr. STEVENS. I do not think it would, taking the length of time we would naturally expect that that amount of 30 feet of water would take to come and the length of dead water it would have before it would reach the prism of the canal, which would be 7 or 8 miles.

Senator MORGAN. When it reached the point of discharge at Gamboa, we will say, then it would flow out into a lake that includes all the distance between Miraflores and Gatun?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And all of the inlets and outlets to that lake?

Mr. STEVENS. Yes, sir; about 115 square miles, we may say.

Senator MORGAN. Is that your estimate of the lake surface that is created by the dam at Gatun?

Mr. STEVENS. Yes, sir.

Senator MORGAN. One hundred and fifteen square miles?

Mr. STEVENS. About 115 square miles.

Senator MORGAN. It seems very reasonable that no flood in the Chagres River that is known could disturb the water over 115 square miles to any serious degree.

Mr. STEVENS. It does not seem so to me; but of course that would not be the material point. The material point would be, would it disturb the water at the point of entrance to the canal prism?

Senator MORGAN. That is the point I wanted to get at. Is there any way, by widening the point through which flood waters from the Chagres would be admitted into the canal, to distribute them by additional cutting out?

Mr. STEVENS. That cutting could be deepened, of course—that is, that basin in the mountains could be deepened to, say, 45 feet, the depth of water in the canal prism proper, over an almost indefinite extent. You could go down 2 or 3 miles if you liked.

Senator MORGAN. You have considered these subjects, I suppose, maturely?

Mr. STEVENS. I have given them serious consideration.

Senator MORGAN. You have studied them?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Is it your opinion, then, that there is any danger of a disturbance of the navigation of the canal or any danger of injury to any part of the canal if a flood of 30 feet should occur in the Chagres River that would rise in, say, twelve hours?

Mr. STEVENS. I should say no, sir.

Senator MORGAN. You would say no?

Mr. STEVENS. Yes, sir; I should say so.

Senator MORGAN. Do you feel entirely confident in that opinion?

Mr. STEVENS. That is my opinion. I am confident about it.

Senator MORGAN. I call your attention to it particularly, because it seems to me that that is the real, central point of inquiry with regard to this whole business after you get your dam elevated and you make the lake. That is the point, and the only point, at which the lake is liable to be attacked by a heavy precipitation of flood water into it from the mountains?

Mr. STEVENS. Yes, sir.

Senator MORGAN. That is the only point?

Mr. STEVENS. That is the greatest point to be considered. I do not think the others are worthy of discussion.

Senator MORGAN. If we can handle that question at Gamboa, then we may consider that every objection is answered on that score as to the precipitation of water from any other stream?

Mr. STEVENS. It would seem so to me; yes.

Senator MORGAN. That is what I wanted to ask about. I wanted to center the attention of the committee, and after a while, probably, of Congress, upon the fact that the resistance that is afforded by the lake waters and the opportunity for the spread of flood waters at Gamboa is sufficient to meet any flood in the Chagres River of, say, 30 feet elevation, and precipitated, say, within twelve hours.

Mr. STEVENS. I think that a rise of 30 feet in twelve hours would probably be abnormal, but still it would be no more than safe to assume that.

Senator MORGAN. That is what I wanted to get at. It would be safe to assume that?

Mr. STEVENS. Yes. That is what we are trying to do—to keep on the safe side.

Senator MORGAN. I have no further questions to ask Mr. Stevens at this time.

Mr. STEVENS. You see, Senator Morgan, the precipitation of the flood you have described, or any other, does not occur in a compact mass, we might say, immediately into the prism of the canal. There is from a third to half a mile of expansion, I may say, or widening, below the Gamboa gap, where this flood would ease out, if I may so express it, before it would strike the navigable channel.

Senator HOPKINS. Then that flood is retarded for a distance of six or seven miles before you get to Gamboa, is it not, by the dead water that is thrown back?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Twelve miles.

Senator HOPKINS. Whatever the distance is.

Mr. STEVENS. I do not know the exact distance from memory, but the maps will show it. It is not less than 8 or 9 miles to the valley line, possibly it is 10 miles.

Senator GORMAN. What makes that dead water? Is it the dam at Gatun?

Mr. STEVENS. Yes, sir.

Senator GORMAN. That is high enough?

Mr. STEVENS. Oh, yes, sir. Those are actual levels. There is no doubt about that. They do not vary, probably, an inch.

Senator KITTREDGE. When did you begin to make borings at Gatun?

Mr. STEVENS. I commenced in September.

Senator KITTREDGE. About what time in September?

Mr. STEVENS. I think the latter part of it. I do not remember the date.

Senator KITTREDGE. Were those borings made under your personal direction?

Mr. STEVENS. Oh, no; they were made by my engineers on the ground.

Senator KITTREDGE. Who had charge?

Mr. STEVENS. Mr. Maltby, division engineer at Colon.

Senator KITTREDGE. Is that the same engineer that was there a year ago last November?

Mr. STEVENS. No, sir; I think not. I think Mr. Maltby went there about in March or April.

Senator KITTREDGE. And from what part of the United States?

Mr. STEVENS. He went from Memphis. He has been with the Mississippi River Commission for a great many years, in charge of their dredging.

Senator KITTREDGE. How long did those borings continue?

Mr. STEVENS. We worked two and three parties there with drills to about the time—yes, after the consulting board came back; we might say to the middle of November or longer.

Senator KITTREDGE. And what were the results of those borings?

Mr. STEVENS. The result showed that something like 200 feet overlying the rock—the so-called “indurated clay”—there was a blanket of clay with a small mixture of very fine sand, and that no permeable material—that is, material that would carry water—was found for a depth of about 200 feet.

Senator MORGAN. Two hundred feet reaching down to the rock?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. In those borings were any materials encountered such as shells and wood?

Mr. STEVENS. I do not think there were. I do not recollect that there was anything of that kind.

Senator KITTREDGE. I call your attention to the statement of the minority, on page 4, and read:

Many of the borings (referring to the borings at Gatun in September, 1905) even at those considerable depths (referring to the depth of 204 feet below the sea level) encountered shells, wood, and vegetable matter, all tending to show that the material had been deposited in currents too sluggish to transport gravel and other coarse material.

Had you in mind that condition of affairs?

Mr. STEVENS. I do not recall the specific details of what was

brought up by the drills, you know. I simply know that the material was fine, as indicating that the currents were slow, no coarse gravel being encountered.

Senator KITTREDGE. In what respect did the result of the borings at Gatun differ from the borings at Bohio?

Mr. STEVENS. Those at Bohio developed the fact that there was coarse gravel, water-bearing strata.

Senator MORGAN. What did the borings at Gatun develop?

Mr. STEVENS. They developed clay and finer material—fine sand, which is considered impermeable.

Senator MORGAN. What you read there, Senator Kittredge, was in regard to the Bohio dam, was it?

Senator KITTREDGE. No, sir; Gatun.

Senator MORGAN. At Gatun?

Senator KITTREDGE. Yes.

Senator MORGAN. Will you read that again, please?

Senator KITTREDGE. I only read one sentence. I will read the whole paragraph [reading from the minority report of the consulting engineers, p. 4]:

The borings made prior to September, 1905, at and near Gatun showed nearly everywhere an admixture of sand with clay and impervious material, with a maximum depth to rock of 204 feet below sea level. Many of the borings, even at those considerable depths, encountered shells, wood, and vegetable matter, all tending to show that the material had been deposited in currents too sluggish to transport gravel and other coarse material.

The borings were "water-jet" or "wash-drill" borings, made by first driving, when necessary, an iron pipe (known as a "casing"), having an inside diameter of 2½ inches, and then inserting a smaller pipe, through which a jet of water was forced, washing the material in the larger pipe through the annular space between the two pipes to the surface of the ground. It was characteristic of these borings, and also significant, that in many cases it was not necessary to drive any casing, or if one was driven it was not necessary to drive it to the full depth, as the material contained enough clay to sustain the sides of the hole without the casing.

Of 27 borings made before September with reference to the location of a dam at or near Gatun, no casing was used in 13 holes, in 8 other holes the length of casing did not exceed 20 feet, while in the remainder the length of casing ranged from 28 to 101 feet; but in no instance was the casing driven much more than halfway down to the bottom of the hole.

The depth to rock was shown to be so great, both at Bohio and at Gatun, that it would be costly and difficult in either case, if not impracticable, to excavate to the rock or to provide any efficient cut-off or stop water extending from the surface of the ground to the rock, and if a dam were to be built without such cut-off the borings showed clearly that there would be much less seepage beneath a dam built at Gatun than at Bohio.

Senator HOPKINS. Does not that show that at Gatun, for a depth of two hundred and odd feet, the material is impervious to water, and that the shells are discovered at a depth of 205 feet? Is not that it?

Senator KITTREDGE. That is what I was desirous of ascertaining from Mr. Stevens.

Senator HOPKINS. If I understood that correctly, it corroborated what Mr. Stevens said. I wanted to see whether I had read that correctly.

Senator MORGAN. Did you make those borings before September?

Mr. STEVENS. No, sir.

Senator MORGAN. Your borings were made since that time?

Mr. STEVENS. Yes, sir.

Senator MORGAN. You are predicating what you state here in regard to the dam at Gatun upon those borings?

Mr. STEVENS. Well, largely on those, of course. I took into consideration all the borings and the fact that the material universally showed that it was a heavy body of clay, with a little admixture of very fine sand, with no gravel.

Senator MORGAN. In the borings you made did you come across any of the conditions mentioned in what has been read by Senator Kittredge?

Mr. STEVENS. I do not recall any timber or shells. I would not say that there were none. I would not regard it as significant, particularly as to the timber. Small particles of timber might be brought down at any time of flood. I do not think that would be significant. I have found petrified wood at the mouth of an alluvial stream 600 feet below the level of the ocean.

Senator KITTREDGE. How many borings in all were made under your direction after you arrived at the Isthmus and began these operations?

Mr. STEVENS. I could not give you the exact number, Senator.

Senator KITTREDGE. About how many were made?

Mr. STEVENS. I should judge there were 40 or 50 at least.

Senator KITTREDGE. Where, with reference to the channel of the Chagres River?

Mr. STEVENS. They were made laterally across the channel. Quite a number were made on the hills, where the proposed location of the locks is, and up and down the streams in the bottom of the valley between the channels.

Senator KITTREDGE. Have you records made showing the exact location of these borings?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. Is that information on file in the office at Washington?

Mr. STEVENS. It was all placed in the hands of the consulting board, and it is either in the office or in their possession. It is available in this country.

Senator KITTREDGE. You say about 40 borings were made in all?

Mr. STEVENS. That I had made; 40 or more.

Senator KITTREDGE. That is what I mean, under your direction.

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. And about how many were made at the location of the triple locks or the proposed triple locks?

Mr. STEVENS. There were probably ten or fifteen.

Senator KITTREDGE. How many were made between that point and the river, going west?

Mr. STEVENS. They started and put them down at different distances from the mountain where the locks were located, and continued across the straight line of the proposed dam, clear across the high ground. I can not tell you the exact number without reference to the records.

Senator KITTREDGE. What is the distance between the location of the locks at Gatun and the other side, the western terminus of the proposed dam?

Mr. STEVENS. About 7,000 feet.

Senator KITTREDGE. Through that distance you made borings to the number of about twenty-five?

Mr. STEVENS. In that vicinity; yes, sir. I am depending upon my memory, you know.

Senator KITTREDGE. I understand, of course.

Mr. STEVENS. I can not tell exactly.

Senator KITTREDGE. Of course. How close were those borings to each other?

Mr. STEVENS. They were different distances apart. In some cases they were 50 feet apart, and sometimes 100 feet apart.

Senator KITTREDGE. Were there any places where they were nearer together than 50 feet?

Mr. STEVENS. I am under the impression that there were. I think they started certain holes and had trouble getting down and started others alongside of them.

Senator KITTREDGE. I refer to perfect borings.

Mr. STEVENS. I do not think there were, no; not perfect borings. You understand that we have cross-section sheets, blueprints showing the exact location and depth of every hole on the map.

Senator KITTREDGE. What do your records show in regard to borings made prior to those for which you were personally responsible?

Mr. STEVENS. They show generally the same state of affairs, the same kind of material that the prior ones show.

Senator KITTREDGE. How far back do they date?

Mr. STEVENS. I could not tell you that. They were made before my time.

Senator KITTREDGE. Do you know whether a great many were made under the direction of Mr. Wallace?

Mr. STEVENS. I could not tell you that. I do not know who made them. I am under the impression that Mr. Wallace had them made. I did not consider that there had been enough made to develop the situation, and that is why I had the rest made.

Senator KITTREDGE. Were there any made under the management of the French?

Mr. STEVENS. I could not tell you that.

Senator KITTREDGE. You spoke yesterday of a dam of any sort at Bohio being possible. Did I understand you correctly?

Mr. STEVENS. I do not quite think you did, Senator.

Senator KITTREDGE. Just what was your view upon the subject of the construction of a dam at Bohio at or near the location recommended by the French and the Walker Commission?

Mr. STEVENS. I do not recall my exact language; but my notion in regard to that is that the foundation at Bohio was not as good as it is at Gatun. The fact that a mountain of permeable material, water-bearing strata, is encountered there would render it a grave question whether the escape of water through that strata would not be very disastrous and would take too much water away from the lake. There is no danger, in either case, of the stability of the dam going up.

Senator KITTREDGE. Your notion, then, is that it would in no manner affect the stability of the dam, but might affect the water supply?

Mr. STEVENS. The water might escape through the gravel at Bohio.

Senator KITTREDGE. For that reason you would regard it as unsafe to construct a dam at Bohio? Is that right?

Mr. STEVENS. I would not say it is unsafe. I say it is largely a matter of experiment, which I do not think would obtain at Gatun.

Senator KITTREDGE. What is your judgment about the Bohio situation? That is what I am getting at.

Mr. STEVENS. In what respect? Would I countenance putting a dam there?

Senator KITTREDGE. Would you advise this committee to recommend to the Senate the construction of a dam at Bohio?

Mr. STEVENS. I should certainly want to cut off some of that flow of water that might possibly occur through the subaqueous foundation. I do not say it must all be cut off, because 163 feet is quite a depth to work.

Senator KITTREDGE. Without its being cut off, you would regard the construction of the dam as inadvisable at that point?

Mr. STEVENS. I would not recommend it.

Senator KITTREDGE. What sort of a dam?

Mr. STEVENS. Why, I would build an earthen dam, in any case, of very large dimensions.

Senator KITTREDGE. But you would not advise even that at Bohio?

Mr. STEVENS. Not without the works being constructed to cut off the flow of water that might possibly occur. It is one of those things that might or might not happen. In a matter of this kind, where we want to be absolutely safe, it would be better, as a matter of insurance, to take that precaution, although it is not a thing that any engineer can say will occur.

Senator KITTREDGE. What is the distance across the valley at Bohio?

Mr. STEVENS. I think it is somewhat shorter than it is at Gatun. Possibly it is about a mile.

Senator KITTREDGE. There is not so very much difference?

Mr. STEVENS. There is not so very much difference, as I recall it.

Senator KITTREDGE. In the event of the construction of the dam at Bohio, what method would you advise to shut off the escape of water that you have mentioned?

Mr. STEVENS. That is a point that has never been decided, even in my own mind. There are several ways in which it can be done. You can drive steel piling or sheet piling down to 60 or 70 feet, possibly 80.

Senator KITTREDGE. Piling of what character?

Mr. STEVENS. Steel overlapping piling. There are other ways in which, probably, the work could be done. We can drill through the loose material holes very close together and fill them with cement, cement mixed with gravel, forced down by pumps, and this cement will set and harden and form a wing that will shut off the water.

Senator KITTREDGE. In other words, you would squirt the cement in?

Mr. STEVENS. That is the word exactly.

Senator KITTREDGE. Putting the cement down beneath the surface of the ground under the water?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. And in that manner you would provide a sort of screen to shut off the water?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. Do you regard that as a satisfactory way to treat the condition?

Mr. STEVENS. It is so considered among engineers. I have had no experience as to that, and can not quote any place where it has been used. The consensus of opinion among the people I have talked with on the subject is that it is satisfactory. It is used by the Germans in a great many cases, and I think it has been used in this country in tunneling where you have wet, heavy ground. You bore ahead and bore ahead and inject the cement and let it set and shut off the flow of water and dig it out afterwards, keeping this work ahead of you all the time. That is supplemented in many cases by the Germans by freezing the ground ahead, which simply solidifies the ground.

George Morrison's opinion, as I remember, was that nothing of the kind was needed at Bohio; but, as I say, I would be a little more conservative, and I would feel a little dubious about the result without some such work as that.

Senator KITTREDGE. You would hesitate about recommending a dam at Bohio of the form that you have suggested?

Mr. STEVENS. Or any dam.

Senator KITTREDGE. That is what I mean—any dam.

Mr. STEVENS. Any dam; unless, of course, it should be a dam which would be practically impossible, a dam going clear to rock.

Senator KITTREDGE. I understand. It is an impossibility, as I understand, to get to rock?

Mr. STEVENS. I think it is.

Senator KITTREDGE. At the depth you find it at Bohio or at Gatun?

Mr. STEVENS. Nothing is impossible with money; but there is a point beyond which it ceases to be an economy.

Senator KITTREDGE. The solid rock below the surface of the water at Bohio is 168 feet?

Mr. STEVENS. I think the deepest boring is 163 feet.

Senator KITTREDGE. One hundred and sixty-three feet?

Mr. STEVENS. The old borings which they thought were rock, but which were boulders, were 128 feet.

Senator KITTREDGE. Yes.

Mr. STEVENS. Those afterwards developed by Mr. Wallace were 163 feet.

Senator KITTREDGE. Are you sure it is not 168 feet?

Mr. STEVENS. I am not sure.

Senator KITTREDGE. My recollection is that it is 168 feet.

Mr. STEVENS. My recollection is that the depths of the borings were 128 feet and 163 feet. I may be wrong, possibly.

Senator KITTREDGE. How is it at Gatun? How far below the surface of the water is the solid rock?

Mr. STEVENS. The deepest there was 204 feet below the sea level, and that is practically the surface of the water.

Senator KITTREDGE. Have I not seen in some of these reports that it was 258 feet?

Mr. STEVENS. I do not think so.

Senator KITTREDGE. Where do you think this water goes that clearly passes under the surface at Bohio?

Mr. STEVENS. That is a question, of course, that I could not answer. It may come out in the depths of the Caribbean Sea, or it may come out at some point in the river.

Senator KITTREDGE. Is it not inevitable that that same fall of water passes under the site of the proposed dam at Gatun?

Mr. STEVENS. It may or it may not.

Senator KITTREDGE. What do you think about it?

Mr. STEVENS. I do not think it does, because the area of the water-bearing material there was so very insignificant that it could not pass under.

Senator KITTREDGE. Suppose you had made more borings, might you not have discovered the same conditions?

Mr. STEVENS. I do not see how we could, when we bored clear across the whole area covered by the dam—the whole width of it—and did not find that condition.

Senator KITTREDGE. If it does not pass down in that direction to the sea, does it come under the mountains or the hills that are—

Mr. STEVENS. It may come up into the river again between Bohio and Gatun.

Senator KITTREDGE. Into the river?

Mr. STEVENS. It may; yes.

Senator KITTREDGE. Have any borings been made to ascertain that fact, if it is a fact?

Mr. STEVENS. Not that I know of.

Senator KITTREDGE. Would you think it advisable that that be done?

Mr. STEVENS. Why, I should not consider it necessary.

Senator KITTREDGE. You answered a question that I asked yesterday, but to have it conveniently in the record here, I will ask you how deep you propose to go for the foundation of the dam at Gatun.

Mr. STEVENS. I propose to dig through the soft alluvial debris on the surface; that is all.

Senator KITTREDGE. And that varies?

Mr. STEVENS. That may be 10 to 20 feet, or something like that—until you get down to the firm clay.

Senator KITTREDGE. In no case deeper than 20 feet?

Mr. STEVENS. I do not think so; no, sir.

Senator KITTREDGE. And in no case less than 10?

Mr. STEVENS. That is my recollection—within those limits. It might vary a few feet, more or less.

Senator KITTREDGE. And at the foundation of the dam it is 2,700 feet thick?

Mr. STEVENS. Twenty-six hundred and a fraction; practically 2,700 feet.

Senator KITTREDGE. As the dam increases in height the width decreases?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. Give the distances as it proceeds in elevation.

Mr. STEVENS. You must understand that I have not made the plans for this dam. I have not even seen the details. Those have been submitted by the advisory board. Although I have never seen a plan, I have the impression that on the down strip side the slope is 1 in 25. In other words, for every foot of rise you go out 25 feet.

Senator KITTREDGE. Your dam is 7,000 feet long and it is 2,700 feet thick at the base?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. It is, as I recollect, 135 feet in height?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. That is, above the surface of the ground. Is that right?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. How thick would that dam be at the surface of the water, as you expect it to be?

Mr. STEVENS. Three hundred and seventy-four feet. I recall that.

Senator KITTREDGE. At what point does the thickness begin to decrease as it rises in elevation—at once?

Mr. STEVENS. Oh, yes.

Senator HOPKINS. He said 1 foot in every 25.

Senator KITTREDGE. Yes. What I meant by that question is, does it begin to decrease at the foundation or at the surface of the country as it now appears?

Mr. STEVENS. Well, they would practically be the same in 20 feet, you know; there would be no difference. Of course, theoretically, it should commence where the line of pressure begins, at the lowest line of the water level, the bottom of the extreme depth of water. There it should commence, and decrease toward the top. I have never seen a plan of the bottom. I have only had it described to me. Of course a dozen different engineers might make a dozen different plans, varying slightly in detail, but the fact remains that at the water level the dam would be 374 feet wide and about 2,700 feet (within 20 or 30 feet more or less) at the base.

Senator KITTREDGE. In reading the report of the minority last night, I noticed that General Abbott recommends the construction of a duplicate lock at Gatun and a third lock at Bohio, or favors that. Have you any suggestions to make to the committee upon that subject?

Mr. STEVENS. No, sir.

Senator KITTREDGE. Do you know the width of the Suez Canal at the bottom and at the surface of the water?

Mr. STEVENS. No; I can not give it to you offhand; but the width at the bottom is something in the vicinity of 150 feet or 160 feet. This report gives it exactly. At the surface, I think, there is now 31 feet of water in the Suez Canal. That is the navigable depth.

Senator KITTREDGE. You may look at these reports, if you wish [the minority and majority reports of the consulting board of engineers].

Mr. STEVENS. That is the navigable depth, 31 feet, which they are now deepening to 34 feet. I do not even know that they give it in these reports. I have it somewhere, but there are so many of these figures that it is pretty hard work for me to carry them in my head. The only thing I carry in my head about the Suez Canal is that there is 31 feet of water. It may be in the other report there. I have not looked at that.

Senator KITTREDGE. It is not worth while taking up time looking for it.

Mr. STEVENS. I do not seem to see it in the index.

Senator KITTREDGE. I will withdraw that question, so that you may look it up a little later.

Mr. STEVENS. Practically it is not to exceed 150 or 160 feet on the bottom. The surface width would, of course, depend entirely on the

slope that is used. That being a sandy country through there, I should imagine it would be about, for a 30-foot depth, probably 300 feet or 350 feet wide on the surface.

Senator KITTREDGE. Before I pursue that inquiry further, I want to call your attention to statements of the majority of the Consulting Board of Engineers upon the question of the Gatun dam. I read from pages 28 and 29:

It has not been proposed to dredge out the soft and yielding material at either place other than possibly a shallow strip of the natural surface, nor has it been proposed to sink a curtain either of masonry or of timber, such as deep sheet piling or of any other material, to cut off percolation or seepage underneath the structure.

These are grave considerations in the design of dams to retain water of depths varying from 30 to possibly 85 feet or more. The subsurface material at Mindi and at Gatun, extending down to the hard, indurated, sandy clay or soft rock, attaining a maximum depth of 258 feet—

There I find the figures 258. Are the board in error in that?

Mr. STEVENS. I can not say from memory about that; I do not know, Senator.

Senator KITTREDGE. The deepest boring that you made at Gatun, as I understand it, was—

Mr. STEVENS. Two hundred and four feet, according to my recollection. Anyhow, we were in indurated clay, whatever the depth may be.

Senator KITTREDGE. And this statement that I have just read indicates that the Board of Consulting Engineers were in possession of information showing that borings had been made at the dam site at Gatun to the depth of 258 feet. That is right, is it not?

Mr. STEVENS. That is the inference from that report.

Senator KITTREDGE. I continue to read:

is in large part of a comparatively fine character, consisting of sand and clay in varying portions and in various degrees of admixture, but the borings have also shown coarse sand and gravel with water flowing through it and out of some of the pipes used in making the examinations.

Did you observe any of those conditions in the examinations or borings that were made under your direction?

Mr. STEVENS. Water came from one of the pipes, as I recall it, from a depth of something like over 200 feet. I do not recall any particular gravel that came up. There was no coarse gravel, as in the case of Bohio there was gravel 2 inches in diameter that would barely come up through the pipes. I do not know what size pipe they used.

Senator KITTREDGE. I continue to read:

As a presumption or speculation it may be stated as probable that most of this material under the weight of an earthen dam would be so nearly impervious that a small or negligible quantity of water only would find its way through, even with the increased head of the reservoir; but that is simply conjecture.

Do you agree with that statement?

Mr. STEVENS. No, sir; I think that the quantity that would go through would be entirely negligible.

Senator KITTREDGE. Do you agree that that is conjecture, as the board suggests?

Mr. STEVENS. No, sir; it is proved, to my mind.

Senator KITTREDGE. In what manner has it been proven to your mind?

Mr. STEVENS. Because I think the nature of the material they drill through would show that the water would not go through, to any extent.

Senator KITTREDGE. I understand; but the only borings under your direction were to a depth of 204 feet?

Mr. STEVENS. That is my recollection. We went to the rock, though, with every boring.

Senator KITTREDGE. The statement is made here, or at least the inference is clear, that the board had in its possession the result of borings to the depth of 258 feet, is it not?

Mr. STEVENS. That is what the report says. I can not recall the exact depth, in my mind. They had access to the records which we furnished them.

Senator KITTREDGE. I continue to read:

It is more than possible, it is highly probable, if not certain, that at various points the material is sufficiently loose in texture to permit seepage or percolation in dangerous quantities.

What do you advise us in regard to the correctness of that statement made by the Board of Consulting Engineers?

Mr. STEVENS. I do not agree with it.

Senator KITTREDGE. And you base it upon the result of your examinations as you have stated them?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. I continue to read:

Nothing is more common in the sandy deposits of river valleys and in all sandy material than small passages or channels through which water moves, varying in size from thread-like openings to those sufficient to yield flowing wells of large discharge. Extended experience in dealing with the underground flow of subsurface waters in many places in the United States, and wherever investigations in that field of hydraulics have been made, show this to be the case.

Senator SIMMONS. Are you reading that from the majority report or the minority report?

Senator KITTREDGE. From the majority report.

Senator SIMMONS. That is what I supposed.

The CHAIRMAN. That relates to both Gatun and Bohio, does it not?

Senator KITTREDGE. Yes. I am speaking of Gatun.

I pass over several paragraphs and read the following on page 29:

The United States Government is proposing to expend many millions of dollars for the construction of this great waterway to serve the commerce of the world for all time, whose very existence would depend upon the permanent stability and unquestioned safety of its dams.

Is that a correct statement?

Mr. STEVENS. The perpetuity of the canal would depend on the safety of the dams. There is no question about that.

Senator GORMAN. At either place?

Senator KITTREDGE. At either place, where there is a lock canal; if you were to have a lock canal. Is that right?

Mr. STEVENS. The safety of the dams must be assured.

Senator KITTREDGE. In other words, the dam, either at Gatun or at Bohio or wherever else it may be decided to place it, if a lock canal is determined upon, must be absolutely safe?

Mr. STEVENS. If you build dams, they must be absolutely safe. There is no question about that.

Senator KITTREDGE. In other words, a safe dam is a key to the integrity of the entire lock canal. That is right, is it not?

Mr. STEVENS. Of course a lock canal can be built without any dams at all.

Senator KITTREDGE. At this point?

Mr. STEVENS. No, sir.

Senator KITTREDGE. Well, we are talking about that, of course, Mr. Stevens.

Mr. STEVENS. You spoke of several points. You spoke of Gatun and Bohio, and the west end, the south end. For instance, you could dig a sea-level canal up to Bas Obispo, where the mountain starts, and then lock there, and it would require no dam.

Senator KITTREDGE. As I understand, none of the plans you now suggest have been recommended by any board or seriously considered?

Mr. STEVENS. Not to my knowledge.

Senator KITTREDGE. The minority of the Board of Consulting Engineers recommends the construction of a dam at Gatun and a lock canal of 85 feet elevation. In order to have any canal at all that dam must be an absolutely safe structure?

Mr. STEVENS. Surely.

Senator KITTREDGE. Passing now from the dam at Gatun to the dam at Gamboa: Under the plan proposed by the Board of Consulting Engineers, as I understand, that Board recommend the construction of a masonry dam at Gamboa for the purpose of controlling the flood waters of the Chagres?

Mr. STEVENS. If I recall their words aright, they say either a masonry dam or an earth and masonry dam.

Senator KITTREDGE. You told me yesterday that the foundations of this dam were laid in solid trap rock?

Mr. STEVENS. At about 50 feet, at the deepest point, you strike the rock.

Senator KITTREDGE. There is no difficulty in reaching the rock at any point at which the dam is to be constructed?

Mr. STEVENS. No, sir.

Senator KITTREDGE. The purpose of that dam is to impound the flood water and then, with proper appliances, to permit the escape of the water at suitable times in the canal and out to sea?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. Is there anything about this dam that makes it impossible to construct an absolutely safe dam?

Mr. STEVENS. Nothing except a faulty design or a faulty execution of the work.

Senator KITTREDGE. And that, of course, you would not count against the structure?

Mr. STEVENS. No, sir. The natural conditions are good.

Senator KITTREDGE. So that the answer is that you would secure an absolutely safe structure at that point?

Mr. STEVENS. As far as human foresight could prevail.

Senator KITTREDGE. Exactly. Is there anything about the purpose of the structure that would make that feature of the sea-level canal a doubtful proposition?

Mr. STEVENS. No; not if the dam were properly built, excepting always the danger of an artificial masonry work from attack in case of war, or something of that sort.

Senator KITTREDGE. Well, there is no more danger in that, then, than in any similar structure?

Mr. STEVENS. I say any artificial work or masonry.

Senator KITTREDGE. Passing for the moment to the tidal lock structure of the sea-level canal, where is that to be located?

Mr. STEVENS. At Sosa—between Sosa and Ancon Hill.

Senator KITTREDGE. Does not the Board, while expressing a preference for that point, indicate that a change may be made in that regard?

Mr. STEVENS. I do not recall their language. I have not read that report for a week or ten days. I could not remember those things.

Senator KITTREDGE. Is there anything to hinder a tidal lock being constructed at Miraflores?

Mr. STEVENS. Not in my opinion; no, sir.

Senator KITTREDGE. At that point the foundation is, as you stated yesterday, in rock?

Mr. STEVENS. The rock is very near the surface there; very near.

Senator KITTREDGE. Do you recall any feature or any condition surrounding that location that would prevent the construction of a tidal lock at Miraflores?

Mr. STEVENS. I do not recall any; no, sir.

Senator KITTREDGE. If the sea-level canal be adopted, what is your judgment about the advisability of constructing a tidal lock at Miraflores, as compared with the location at Sosa?

Mr. STEVENS. My predilection, as I explained yesterday, is in favor of putting locks in any type of canal at Miraflores rather than at Sosa.

Senator KITTREDGE. On the sea-level canal, as recommended by the Board of Consulting Engineers, there are, then, two dams to be built—one at Gamboa, for the purpose of controlling and impounding the flood waters of the Chagres, and the other structure is the tidal lock at Miraflores or Sosa or some point on the Pacific side?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. And I understand you to say there is nothing in either of those propositions presenting any unusual difficulties?

Mr. STEVENS. I do not think so. My preference, as I explained, for placing artificial works farther inland was largely on account of the military point of view.

Senator KITTREDGE. Yes; I so understood you. On the lock canal, with the elevation recommended by the minority of the Board of Consulting Engineers, you have the dam and triple locks at Gatun, which you have described; then you eliminate the dam at Gamboa, which is recommended by the Board in favoring the sea-level canal. You have a lock at Miraflores of about 30 feet?

Mr. STEVENS. I think that is at Pedro Miguel. They are both together, within a mile or so.

Senator KITTREDGE. Well, in that vicinity, I mean—Miraflores or Pedro Miguel?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. And then a duplicate lock in the vicinity of Ancon or La Boca, of an elevation of 55 feet?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. That is right, is it?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. The duplicate lock means the construction of three dams, which you described yesterday. Is that right?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. And the aggregate length of those dams is what?

Mr. STEVENS. I do not remember that I gave the aggregate length. I think the longest would be about three-quarters of a mile, across the valley of Rio Grande; another, between the two mountains, Sosa and Ancon, about one-third of a mile; and the third, from Ancon to what is called the "Corozal Hills," which would be, I should judge, about a mile or a mile and a quarter; altogether making, say, probably two miles and a quarter. That is only a general statement, judging from the map.

Senator KITTREDGE. I understand.

Mr. STEVENS. I have walked over the ground and been over it, of course.

Senator KITTREDGE. That is sufficient for the purpose. What is the character of the soil at the point of these two dams?

Mr. STEVENS. It is clay.

Senator KITTREDGE. What do you say about the foundation there, as compared with the foundation at Gatun?

Mr. STEVENS. I should say that the material shows that it is impermeable in both places. The rock, of course, is comparatively near the surface through this section of the country down there at this particular place—that is, at Sosa, and all through that country.

Senator KITTREDGE. Do you propose to go down to the rock with the dams at the points that you have described?

Mr. STEVENS. No, sir.

Senator KITTREDGE. Then the distance to the rock in the plans adopted by the minority is of no special significance?

Mr. STEVENS. I think not.

Senator KITTREDGE. And is it your judgment that the material upon which the foundation of those dams would be laid is substantially the same as at Gatun?

Mr. STEVENS. Well, I suppose that no two materials—

Senator KITTREDGE. I mean so far as stability is concerned?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. I read now from page 29 of the majority report, or the report of the Board of Consulting Engineers, as follows:

The dam at La Boca, between San Juan Point and Sosa Hill, unless carried down to bed rock at that location, would be placed upon a far worse foundation even than that proposed at Gatun or Mindi.

What do you say about that?

Mr. STEVENS. I say that is their opinion; it is not mine.

Senator KITTREDGE. I am asking you for your opinion, of course. That is the purpose of this inquiry—to find out what you think about it.

Mr. STEVENS. I do not think so.

Senator KITTREDGE. "The La Boca site," I continue to read—

is one covered by an ooze of mud and silt, with some sandy material overlying the rock. It is practicable to construct here an earth dam, with a heavy masonry core running down to bed rock, whose stability would be beyond question. Such a structure would be far more costly than a great amount of earth placed upon the mud and silt forming the natural bottom of the Rio Grande

estuary. Unless some feature equivalent to that of a heavy masonry core characterizes the design of the dam at this point, or unless resort be made to dredging down to bed rock or near to it and refilling with suitable material, or an earth dam at this location be made very massive, it would, at this location, be in grave danger of being pushed bodily out of place by the pressure due to the head of water in the reservoir.

Is that your opinion?

Mr. STEVENS. My opinion is that the saving clause is right there—"or if it was made of massive construction."

Senator KITTREDGE. Then do you approve of that suggestion, or do you differ with it?

Mr. STEVENS. I approve of this—that if the dam was made of large size it would be sufficient. I would not undertake to put a little, small, narrow, thin dam in there and suppose that it would stay. I would not do that anywhere, even on solid rock.

Senator KITTREDGE. I continue to read, as follows:

The United States Government is proposing to expend many millions of dollars for the construction of this great waterway, to serve the commerce of the world for all time, whose very existence would depend upon the permanent stability and unquestioned safety of its dams, and the Board is of opinion that the existence of such costly facilities for the world's commerce should not depend upon great reservoirs held by earth embankments resting literally upon mud foundations or those of even sand and gravel. The Board is unqualifiedly of opinion that no such vast and doubtful experiment should be indulged in; but, on the contrary, that every work of whatever nature should be so designed and built as to include only those features which experience has demonstrated to be positively safe and efficient.

What suggestions have you to make upon that recommendation?

Mr. STEVENS. None.

Senator HOPKINS. What do you mean by "none?" Do you mean that you approve of that or that you disagree with it in toto?

Mr. STEVENS. Why, certainly; I think it goes without saying that anything that is built should be built to stay.

Senator HOPKINS. Where you differ with them is as to the character of construction that you have indicated at Gatun and at La Boca?

Mr. STEVENS. Yes, sir.

Senator HOPKINS. You think that is of a permanent character and will stand all pressure that may come upon it?

Mr. STEVENS. I should so regard it, else I would not recommend it.

Senator GORMAN. Is your conclusion in that matter based on the same data that were before the board of engineers?

Mr. STEVENS. Yes, sir.

Senator GORMAN. You have no other or different data from what were submitted to them?

Mr. STEVENS. No, sir.

Senator KITTREDGE. I asked you a few minutes ago about the width of the Suez Canal at the base and the surface of the water; and I think you said it was about 150 or 160 feet wide at the bottom, and that the width at the surface of the water would depend upon the slope of the banks.

Mr. STEVENS. That, of course, Senator, is simply a guess. I do not recall. I know in a general way that it is a narrow canal.

Senator KITTREDGE. How does the size of that canal compare with the size of the canal recommended by the majority of the Board of Consulting Engineers?

Mr. STEVENS. To answer that question in fairness to myself, I should have the exact figures, I think.

Senator KITTREDGE. I will be glad to give them to you.

Mr. STEVENS. I do not know whether they are given there or not. We all know from the statement I have drawn off what the exact width of the canal as proposed by the sea-level proposition is. We had it here yesterday. [After being handed copy of majority report.] I am not sure that this even gives a description of the Suez Canal. I know I have it in one of my notes somewhere. [After examining majority report.] I have those here now. I find that I was mistaken; it is a great deal narrower than I said. [Reading:]

It is a sea-level canal without locks, and has a depth of 31 feet 2 inches—

I had that right—

which is now being increased to 34 feet 5 inches. The bottom width in the canal proper varies from 108 feet, where the side slopes are very flat, to 118 feet, where the side slopes are steeper, with garages, or passing places, at intervals for vessels of large size, as such vessels are not allowed to pass each other while both are in motion.

Senator GORMAN. You are now referring to the Suez Canal?

Mr. STEVENS. Yes, sir.

In order to avoid this difficulty, widening operations are in progress, by which the passing places will be united and the bottom width of the canal increased to a minimum of 147 feet 6 inches.

There is probably where I got the "150" in my head. It is being widened to that extent. They do not give the slopes, and they do not give the top width.

Senator KITTREDGE. With that information, are you able to answer my question?

Mr. STEVENS. Now, you will bear in mind that at present—or do you want to take it after the widening is done?

Senator KITTREDGE. After the widening is done.

Mr. STEVENS. I think that canal is about 90 miles long. The average will be 147 feet and the depth 34 feet 5 inches. Out of the 49 miles of the Panama Canal we have 21 miles of 150 feet width at the bottom—almost exactly the same as the Suez. Then we have 18 miles of 200 feet width; then we have 3.9, say, 4 miles, of 300 feet width, and 4.7 miles of 500 feet width.

Senator GORMAN. This is the sea-level canal?

Mr. STEVENS. Yes, sir. So, as regards width, something like 40 per cent of the Panama Canal will be of the same width as the Suez Canal.

Senator KITTREDGE. That canal has been successful in its operations, with the width that you have stated?

Mr. STEVENS. Oh, yes.

Senator KITTREDGE. I call this to your attention in connection with your statement, as I understood it yesterday afternoon, that the sea-level canal recommended by the Board of Consulting Engineers was in your judgment too narrow for successful operation; that you would have to haul your vessels up and await the passage of a ship going in the other direction, etc.

Senator HOPKINS. That is what they do on the Suez Canal, is it not?

Senator KITTREDGE. I understand that.

Mr. STEVENS. I think the conditions are entirely dissimilar.

Senator KITTREDGE. That is just the point I was getting at.

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. In what respect are they dissimilar?

Mr. STEVENS. I think the curvature of the Panama Canal is greatly in excess of that of the Suez Canal. That can be determined, of course, by getting a correct map of the Suez Canal.

Senator KITTREDGE. Let me ask you, right there, this question: Where there is any curve in the canal at Panama the canal is wider, is it not?

Mr. STEVENS. I do not understand that it is, under the sea-level proposition. The lock canal does not propose any curve at all.

Senator KITTREDGE. Are you quite sure that under the sea-level proposition, where there may be a curve, the canal proper is no wider?

Mr. STEVENS. If I should build such a canal, I should certainly make it wider. It would be absolutely necessary. But I can not say whether, in their details, they have taken that into consideration or not. It certainly should be wider, of course; there is no question about that.

Senator KITTREDGE. Yes. So that, taking into consideration whatever curve there may be, the canal is enough wider to make—

Mr. STEVENS. It must be made wider, certainly. What I referred to in regard to the conditions being different—

Senator KITTREDGE. So that in that regard the point that you suggest may not be well taken; or is it?

Mr. STEVENS. That would depend on the amount that you widened it, of course. There is a certain point that you can widen it to where your curve disappears. If you will allow me to finish in regard to Suez—

Senator KITTREDGE. Certainly.

Mr. STEVENS. This is merely a suggestion, but I think it carries weight. At Suez the canal is dug through a low, sandy country—a desert—with little or no rainfall, and very hot all the time. Aden, on the Red Sea, at the eastern terminus, is probably the hottest place that is inhabited in the world, so far as we have any records.

There is very little rainfall; the records will show what it is. There are no streams entering it. There are no torrential rains—nothing of the sort. It is simply a channel between the two seas—through a flat, sandy desert. I believe the deepest cutting is not over 90 feet.

Here we are constructing a canal through a range of mountains, in a country where the rainfall ranges from 135 inches to 65 at either end.

Senator KITTREDGE. That is, 135 inches at Colon?

Mr. STEVENS. Yes, sir.

Senator KITTREDGE. And 65 at Panama?

Mr. STEVENS. Yes, sir; with numberless large and small mountain torrents—some of them, in flood times, veritable rivers—which must be taken care of, many of them coming directly into the canal, carrying in, as they must inevitably, silt, perhaps trees, mountain débris of all sorts, rocks, bowlders, etc.; so that I hardly think a comparison between the canal at Suez and one of the same dimensions at Panama is a fair one. That is the point that I wanted to make.

If you will allow me, I will say this at this point, not in the nature of an examination, but more of an explanation that is due to me: As I said yesterday, I do not pose as being the expert of the Canal Commission, or anybody's expert. The work of getting the design of the canal was practically taken out of my hands. You will all admit that that is fair to me.

Senator KITTREDGE. Certainly it is.

Mr. STEVENS. So that when I say I do not know definitely about some point, I am honest in it. I am not trying to "side step." It is simply because I do not know. I understand that many navigators, canal experts, canal engineers, and maritime men claim that a curve in a canal is a mistake. (Now, this is something, of course, that does not apply to a lock canal any more than it does to a sea-level canal; it is without prejudice to any type.) They say that instead of having curves, as we lay them out on a railway, a long, swinging distance, to subtend an angle, the two tangents of the straight line should be brought to a point, you see; just the same as a man would walk to a street corner and then turn an angle right at that point instead of making a long swing.

Then, at that point, the prism of the canal should be widened inside of the intersection of these two tangents, so that, in effect, instead of the ship making a rounding curve, changing her tiller all the while, she follows those range lights (supposing that there are two range lights that she is sailing for, for the central line of this canal) until she gets to a certain point where those range lights change. They change instantly. Then she throws her tiller all at once and makes her turn just as quickly as she can, and goes on her new course.

These men claim that that is the way to navigate a canal. I talked with several members of the advisory board while they were on the Isthmus, particularly Mr. Hunton, who was the chief engineer of the Manchester Canal; and I find on talking with some of our men in this country, particularly Mr. Ripley, who was also a member of the advisory board, that they recommend it very strongly; and it would seem to me that there may be force in that. I understand, if I read the minority report right, that they considered it entirely a matter of detail, as it did not affect the cost of the canal particularly.

So when we speak of curvature we must recollect that it is not curvature under that plan; it is simply an abrupt turn. Of course the ship will drift a little under her steerage way, but the effort is made to make her turn at one point. I have noticed, too, in entering harbors, that a vessel never makes a long swing when she comes from one course to the other. She goes where she goes on that course, and then she turns and goes the other way.

I just mention that, thinking that it may be of interest to you gentlemen. It does not have any particular bearing on the type of the canal one way or the other.

Senator KITTREDGE. We are glad to hear your suggestion, of course.

Mr. STEVENS. I can see this, though, without being a seaman, and I think we all can, that with range lights on a series of broken courses of straight lines it would be much easier to handle a ship around an angle than it would to undertake to make a gradual turn of that ship in a narrow channel.

Senator KITTREDGE. That suggestion contemplates the running of boats at night, I understand?

Mr. STEVENS. Oh, I should suppose that if you built a canal at Panama you would build it to operate through the twenty-four hours. I do not see how you could well do otherwise.

Senator MORGAN. In the case that you mention the thing that the ship most needs for safe navigation is turning room at the intersection of these angles?

Mr. STEVENS. Yes, sir.

Senator MORGAN. That is the proposition?

Mr. STEVENS. Yes, sir.

Senator MORGAN. There is something about this south end of the canal that I have not quite straight in my mind, and I want to see if I am right about it. Miraflores is virtually at the foot of the hill—the foot of the ridge?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Am I right about that?

Mr. STEVENS. Yes, sir. It is really, Senator, about a mile or a mile and a quarter from where the bottom sinks—from the lock at Pedro Miguel.

Senator MORGAN. And from that point out to sea it is what we call level—

Mr. STEVENS. It is tide flats. The tide practically comes up at high tide to Miraflores.

Senator MORGAN. They are tide flats?

Mr. STEVENS. Yes, sir.

Senator MORGAN. These two proposed routes, the sea-level canal and the lock canal, both go to Miraflores?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And they diverge at Miraflores, or near there?

Mr. STEVENS. Yes, sir.

Senator MORGAN. One goes between Sosa Hill and Ancon—that is the sea-level canal—and the lock canal goes to the westward of Sosa Hill?

Mr. STEVENS. Yes, sir.

Senator MORGAN. And then out to the sea, both of them; and you have stated that a little stream of water, or river (as they call them out there), passes between Sosa Hill and Ancon?

Mr. STEVENS. I do not think I stated that. If I did, it is incorrect. There is not; no, sir.

Senator MORGAN. It is marked on the map as going through there—the Quibadal, or something like that.

Mr. STEVENS. Between the mountains?

Senator MORGAN. Between Sosa and Ancon.

Mr. STEVENS. Oh, no; that is a mistake.

Senator MORGAN. It is a mistake?

Mr. STEVENS. Yes, sir.

Senator MORGAN. I so read it on the map.

Mr. STEVENS. I am over that ground every day of my life when I am in Panama, and I do not think there is even a culvert there.

Senator MORGAN. Now, take the country from the gap between Sosa Hill and Ancon and run back, now, to Miraflores, in the straightest line you can make—what sort of a country does that line pass through?

Mr. STEVENS. It passes through a low, swampy country, covered with mangrove brush, with the exception of one stretch that I presume is about 2,000 feet in length, measured along the line.

Senator MORGAN. The whole distance, then, or nearly the whole distance, between this gap which we speak of and Miraflores, through which the sea-level canal is proposed to run, is a swampy country?

Mr. STEVENS. With the exception of this half mile of rock.

Senator MORGAN. A half mile of rock?

Mr. STEVENS. Yes, sir; that is, rock which comes above the surface.

Senator MORGAN. That occasions the building, as I understand it, of an embankment practically reaching from Miraflores to the gap between the two hills?

Mr. STEVENS. Yes, sir.

Senator MORGAN. About what is the length of that embankment?

Mr. STEVENS. It is about 4 miles.

Senator MORGAN. And it runs through a flat country, with the exception of this rock hill of which you speak?

Mr. STEVENS. Yes, sir.

Senator MORGAN. One of these swampy countries. What would be a safe embankment there to protect a sea-level canal for a distance of 4 miles?

Mr. STEVENS. I should say that the material dredged from the canal itself, put in there with hydraulic pumps, would be all right—a good, wide levee.

Senator MORGAN. What would be the probable height of such an embankment?

Mr. STEVENS. It would only be necessary to carry it high enough to keep the tidal waters out—I should say not to exceed 6 feet.

Senator MORGAN. By "tidal waters" you mean the waters that come from the sea?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Would that embankment be necessary on both sides of the canal going to this gap?

Mr. STEVENS. No; I do not think it would. Some provision, however, should be made to take care of the waters that come in from the east side, the small streams that come in.

Senator MORGAN. That is what I wanted to get at.

Mr. STEVENS. Yes, sir.

Senator MORGAN. They are numerous?

Mr. STEVENS. Well, the country there is all cut up by little bayous and by water that comes from the hills. I do not think there are over a couple of streams that amount to much in their size.

Senator MORGAN. But they are very crooked in their course?

Mr. STEVENS. Yes, sir; very.

Senator MORGAN. And have to be shut out of the canal?

Mr. STEVENS. Yes, sir; either shut out or brought in so that they would not cut the walls of the canal at all.

Senator MORGAN. The canal there would be 40 feet below sea level?

Mr. STEVENS. Yes, sir; that is what they figured on.

Senator MORGAN. And about what would be the width on their proposition?

Mr. STEVENS. They figured on 300 feet.

Senator MORGAN. Three hundred feet?

Mr. STEVENS (after referring to profile). No; 200 feet.

Senator MORGAN. A canal 200 feet wide?

Mr. STEVENS. Two hundred feet wide on the bottom.

Senator MORGAN. On the bottom, and 40 feet below mean tide?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Now, the eastern side of that canal would have to be protected for about 4 miles in order to shut out those waters that come from the small streams?

Mr. STEVENS. Well, I would not say that. I say that on the eastern side there is about 4 miles where the water comes in.

Senator MORGAN. Yes.

Mr. STEVENS. It is possibly the intention of the sea-level engineers to allow that water to come directly in it. I do not know whether the report bears on that or not. I do know that they propose to make a dike or levee to keep the tidal waters from coming into the side of the canal.

Senator MORGAN. That would be on the western side of the canal?

Mr. STEVENS. Yes, sir.

Senator MORGAN. What would be the length of that dike?

Mr. STEVENS. The same length, practically.

Senator MORGAN. Four miles?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Then you would have 4 miles of dike on either side of the canal?

Mr. STEVENS. You would have if you diked out the fresh water.

Senator MORGAN. If you shut out these waters?

Mr. STEVENS. Yes, sir.

Senator MORGAN. In order to keep the channel of the canal free of the intrusion of outside waters, you would have to have a dike on both sides?

Mr. STEVENS. For about 4 miles.

Senator MORGAN. About 4 miles in extent?

Mr. STEVENS. Yes, sir—that is, on either side—in the neighborhood of 7 or 8 miles, counting both sides.

Senator MORGAN. Together?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Now take the dike on the western side; that is intended to shut out the tides—the sea waters?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Would it not be necessary to have that dike very strong, very compact, and very firm, so as to meet the possible inflow of waters ahead of a storm or wind on the top of a tide?

Mr. STEVENS. I do not think, Senator, that that would require anything more than the earth construction, for this reason: The way I would build that would be, first, to put in what I would call a "dipper dredge;" then I would cut a comparatively narrow channel through the swamp near the west line of the canal, you see, simply to float my larger dredge. Of course, with the arm of the dipper I would throw that material over on the bank. That would form a small wall of earth between the location of the dredge and the country back. Do I make myself clear?

Senator GORMAN. Perfectly.

Mr. STEVENS. That would be what I call my "dipper dredge"—one of those that come down this way, then swing over and drop the material off at the side.

Then I would follow that up with a big hydraulic dredge in this channel, and pump the balance of the material taken from the canal right over this small dike that was thrown up by the smaller dredge, and let that material go back and take its own slope. Naturally, with the amount of water in it, it would take a slope of probably about 1 in 50, perhaps 1 in 40, or 1 in 30. In other words, it would be very, very flat. Now, if you have noticed it, the best protection that nature makes anywhere in the world against tides, against current wash, is a flat slope made of almost any material.

Senator GORMAN. Is it better than riprap?

Mr. STEVENS. Yes; it is better than riprap. Fine sand, fine beach sand, lying on a very light slope, is the very best protection you can get from sea waves, simply for this reason: The waves will run up on it, and will be led up, as you may say, until they lose their force.

Now, it has generally been found, in the last few years, by the best construction engineers, that instead of using abrupt masonry walls to withstand the force of mountain currents or the heavy beating of waves, a much lighter slope is more effective, for that reason.

Of course there will be a vast amount of material, and those dikes could be built at least twenty times thicker and stronger than would probably ever be necessary; but the outside slope, allowing it to take its own slope that way, would be so light that I do not think storms would have any effect on it, particularly as it is landlocked and there is no way for storms to get at it. It would be simply the effect of tide wash.

Senator MORGAN. Is not the pressure upon a flat embankment, such as you speak of across that 4 miles of area, identical in principle with the pressure that would be exerted by the waters upon the dam at Gatun?

Mr. STEVENS. With the exception that there would be a rush of the tide at this point, the absolute weight of the water, of course, would be the same under any circumstances, depending on the depth.

Senator MORGAN. Would the pressure from the tide on that embankment be anything like equivalent to the pressure on the Gatun dam from the waters connected with the lake?

Mr. STEVENS. Oh, no; because of the greater depth of the Gatun dam, which gives greater pressure.

Senator MORGAN. The reason being, I suppose, that the tide in reaching that point would have to rise very considerably in level before it got to it?

Mr. STEVENS. Oh, yes. The tide never would rise more than 4 or 5 feet alongside of this levee.

Senator MORGAN. Not more than 4 or 5 feet?

Mr. STEVENS. That is as I remember it: it is very little. This levee that they speak of is rather an insignificant affair, you know.

Senator MORGAN. It is?

Mr. STEVENS. Oh, yes. There would be no sense in building a high dam there or anything like that. That feature is perfectly practicable.

Senator MORGAN. The lock canal proposes to go to the westward of this proposed embankment, which would carry it to the westward of Sosa?

Mr. STEVENS. Yes, sir.

Senator MORGAN. Would the lock canal have to be protected in the same way?

Mr. STEVENS. Oh, no.

Senator MORGAN. It would not?

Mr. STEVENS. In the case of the lock canal there would be no particular channel through the greater part of that section, you know, because the 55-foot depth would extend there for a width of probably a mile and a half.

Senator MORGAN. And the lock canal would go through a lake, whereas the sea-level canal would go through the earth?

Mr. STEVENS. Yes, sir; that is, according to the minority report.

Senator MORGAN. Yes, I know; with embankments on either side to protect it wherever they thought it was necessary to protect the canal against the intrusion of water?

Mr. STEVENS. Yes, sir.

Senator MORGAN. That is the situation. I just wanted to get it clear in my mind.

Senator KITTREDGE. Mr. Stevens, if a sea-level canal could be constructed at the same cost and in the same time that a lock canal could, as recommended by the minority of the Board of Consulting Engineers, which canal would you prefer?

Mr. STEVENS (after a pause). I am afraid I would prefer the lock canal, Senator.

Senator KITTREDGE. Why?

Mr. STEVENS. Because I think that the passage of ships would be quicker. I think the cost of operation would be no more—if more, very little—in case of a lock canal. I think the cost of maintenance of a lock canal would be very much less. I think the passage through a lock canal will be safer. I think, in case future developments should require enlargement, the lock canal can be made of much larger capacity very much more quickly and cheaply than the sea-level canal. I recollect having some figures made not very long ago, I think since I came to Washington—I was thinking of them at noon—which were to this effect:

With a sea-level proposition, taking the same unit prices which are allowed by the full board, without any dissent, the cost of widening a sea-level canal of 49.7 miles 1 foot—you understand what I mean, simply widening it 1 foot, 12 inches—would be \$870,000. In other words, to widen this entire canal from 150 feet, which is its width for the greater portion of its length, 100 feet would cost \$87,000,000.

Senator HOPKINS. Eighty-seven million dollars?

Mr. STEVENS. Yes, sir.

Senator GORMAN. To widen it the entire length 1 foot?

Mr. STEVENS. One hundred feet, making it 250 feet wide instead of 150; that is, widening it 100 feet. Have I made that clear?

Senator KITTREDGE. Yes; we understand your position about it.

Senator GORMAN. Mr. Stevens, as I understand you, you are in favor of the lock canal of 85 feet elevation?

Mr. STEVENS. I am in favor of that as between the two reports; yes, sir.

Senator GORMAN. I thought that was your conclusion, that you preferred that to any other elevation.

Mr. STEVENS. I think I said yesterday that I differed a little with the minority at the south end in regard to the dam there—not that I

questioned the stability of the dam, but that for military and sanitary purposes, particularly military purposes. If the canal is not to be made neutral I would prefer putting my artificial works at Miraflores and Pedro Miguel.

Senator GORMAN. How much would that raise the elevation of the canal?

Mr. STEVENS. As I have stated, about \$6,000,000.

Senator GORMAN. No; I mean the elevation.

Mr. STEVENS. Instead of the high summit level coming clear through here I would stop it here [indicating] and make it sea level from here out, instead of sea level to here [indicating].

Senator GORMAN. That would still leave your summit level at 85 feet?

Mr. STEVENS. Yes, sir; the reason I favor that is because of the point brought out yesterday—the control of the floods of the Chagres.

Senator GORMAN. Yes. That is, of course, more a military proposition than anything else?

Mr. STEVENS. Military and sanitary; yes.

Senator GORMAN. Military and sanitary. But in either case, whether it was done at that line or at the point proposed by the minority of the Commission, the central point of the success of the whole proposition is the dam at Gatun, as I understand you?

Mr. STEVENS. Yes, sir.

Senator GORMAN. And you are perfectly clear in your own mind that that can be controlled with an earthen dam of the description which you have given?

Mr. STEVENS. Yes, sir; I am satisfied of it.

Senator GORMAN. That would go down to within 200 feet of rock?

Mr. STEVENS. Yes, sir.

Senator GORMAN. Now, will you not explain to me—I can not get that very clear in my head from this map—the location of the three locks to overcome that elevation from the sea level? Is this east?

Mr. STEVENS. That is north.

Senator GORMAN. Where are the three locks by which you overcome the difference in elevation between the sea level and the surface of the water here?

Mr. STEVENS. This map is not very clear. For instance, it shows a little creek running in there. I do not recall any such creek. Now, you see, that [indicating] indicates, in engineering or surveying parlance, swamps. The map shows swamps in there. As a matter of fact, there is nothing of the kind there. There is simply room for the railway track and a row of small houses, not over 100 feet. This hill commences to rise very fast up to 85, 90, and 95 feet.

Senator GORMAN. Yes.

Mr. STEVENS. And there is where they propose to put the locks—right through that high ground there.

Senator HOPKINS. Is that for the sea-level canal?

Mr. STEVENS. No, sir; for the lock canal. It is the point where that gentleman's house is situated—you recollect it there, close to the station. His house is right on top of the high hill, about there [indicating].

Senator GORMAN. Under that plan the foundation of your lower lock must be, of course, below the sea-level part of your canal?

Mr. STEVENS. Yes, sir.

Senator GORMAN. What sort of a foundation can you get for this immense structure?

Mr. STEVENS. Clay.

Senator GORMAN. You would trust that lock on a clay foundation, would you?

Mr. STEVENS. Yes, sir.

Senator GORMAN. A lock 100 feet in width and 1,000 feet in length?

Mr. STEVENS. Nine hundred and ninety-five feet, to be exact; yes, sir.

Senator GORMAN. Yes. Do you think that is safe?

Mr. STEVENS. Why, there is an endless amount of buildings that weigh a great deal more than that lock—twelve, fifteen, and twenty stories high—placed on similar foundations.

Senator GORMAN. Is that so?

Mr. STEVENS. In fact, in Chicago the foundations are very much worse, you know.

Senator GORMAN. Now, following that up—

Mr. STEVENS. You see, the lock has a very broad base.

Senator GORMAN. Yes; it has a broad base. Is it to be made of stone or concrete?

Mr. STEVENS. Concrete.

Senator GORMAN. How does that compare in weight with stone?

Mr. STEVENS. They are about the same. Both of them weigh about 170 pounds to the cubic foot.

Senator GORMAN. Would you build on piles there?

Mr. STEVENS. Not unless something developed there that I do not know of now. In that case piles would, of course, be used.

Senator GORMAN. That first lock would raise you 35 feet, or whatever it is?

Mr. STEVENS. Yes, sir. I am not certain, Mr. Senator, without going to the records and without going to the borings, but what that lock will be constructed in indurated clay—soft rock.

Senator GORMAN. I see. The next lock is what distance south of that?

Mr. STEVENS. They come right together, like this [indicating].

Senator GORMAN. But you have to have a space between them, do you not?

Mr. STEVENS. The vessels will go directly from one lock to the other. There is only a gate between.

Senator GORMAN. But in the case of a ship 1,000 feet in length, or 800 feet in length, you have to have a basin between the two locks, do you not?

Mr. STEVENS. Oh, no; you go right from one gate to the other—from one lock to the other.

Senator GORMAN. Is that the fact with all three of them?

Mr. STEVENS. Yes, sir.

Senator GORMAN. Those are to be double locks?

Mr. STEVENS. Yes, sir.

Senator GORMAN. You mean by that side by side?

Mr. STEVENS. Yes, sir; and these locks up here—this hill is practically all indurated clay. There is only a very thin sheet of anything else.

Senator GORMAN. There is no question about the foundation, then?

Mr. STEVENS. I should not think there was, Senator; no, sir.

Senator HOPKINS. You think the foundation is better than the foundation upon which those immense buildings in Chicago are constructed?

Mr. STEVENS. Why, I know it, as far as a man can know anything. You know, of course, what the Chicago material was.

Senator GORMAN. In constructing this dam I understand that you have to cut a channel around here, around the side of the hill, to prevent the Chagres River flowing over the canal construction, do you not?

Mr. STEVENS. Not at that point.

Senator GORMAN. Do you construct a dam?

Mr. STEVENS. You see that little point there, do you not?

Senator GORMAN. Yes.

Mr. STEVENS. There is a large hill there, and it is proposed to put it through there.

Senator GORMAN. And change it from its present channel?

Mr. STEVENS. Well, there are several channels. There are two channels which are not shown there; but there is another channel here, which is what is called the west diversion. Then there is a channel here, and a small channel through here. That map, you know, is very general.

Senator GORMAN. I see; so that you change the whole flow of the river when you construct this dam across there?

Mr. STEVENS. Yes, sir.

Senator MORGAN. I would like to point out to you this stream we were talking about a while ago. Here is the little stream I was speaking of [indicating]. It originates here, right at the coast.

Mr. STEVENS. That stream does not run through there. There is nothing but the sluggish, swampy ground here, where cattle go out and feed and walk up to their knees in water. This is a wagon road, which runs from Panama out to La Boca. I go over it almost every day, walking or riding, for exercise in the morning, and my recollection is that there is not even a culvert that big there [indicating].

Senator MORGAN. There is no stream there, then?

Mr. STEVENS. Why, you would not know it was a stream. It is a marsh, and undoubtedly the drainage from it goes that way [indicating]. There is nothing that comes through.

Senator HOPKINS. In the case of a sea-level canal is there any dam on the Gatun side of the canal?

Mr. STEVENS. No, sir.

Senator HOPKINS. None whatever?

Mr. STEVENS. There are some levees to keep the side water from coming in at different points.

Senator HOPKINS. What are they? Describe them, if you please. That is the matter that I have not clear in my mind.

Mr. STEVENS. I can not give you the numbers nor the location of them. That is a very big, wide, flat, swampy country down there, with these influent streams coming at different points into the main Chagres River. Certain of those streams, particularly from Bohio down to the coast, they propose to take through new channels. Some are new and some are old. Some the French laid out, which they proposed to enlarge and complete. For instance, we will assume that that stream [indicating] comes down in here somewhere. To

keep it out of the canal they would dig a channel right along here, parallel with the canal, carry it off across the country here 5 or 6 miles, and run all of those streams into it. The banks of that little diversion canal, as we will call it, would at some places be flat; they would be low banks, and in time of high water the water would tend to come out over as it comes out over the bank of ponds in floods.

Now, here is an artificial dike along here. In other words, we raise the natural bank of that stream to keep the water confined to the channel. There are a number of those places, and when they submit maps (which I understand we should have in two or three days, possibly before the end of the week) they will outline all of those on the maps.

Senator HOPKINS. That is all that I wanted to ask you. I did not have that matter in my mind as clearly as I wished.

The CHAIRMAN. Mr. Stevens, I think we are through with you, so far as I know, and we are very much obliged to you.

Senator MORGAN. We congratulate you, sir.

Mr. STEVENS. I want you to understand my position, gentlemen. I have talked here a great deal, and I am not a very good talker, but—

Senator KITTREDGE. I am not so sure of that.

Mr. STEVENS. If I had been directed a long time ago to study up the conditions and formulate a plan absolutely (as perhaps no one man ought to be), I would have been very much more sure in many of the statements I have made. But the statements that I have made as absolute, in my opinion, I am ready to stand for as far as my opinion goes, and I think you will find that some pretty good engineers are of the same opinion. I want to thank you for your courtesy.

The CHAIRMAN. We thank you.

Senator GORMAN. In view of that statement, let me see if we have your exact idea—or if I have, at least. It is that with the knowledge you have obtained down on the Isthmus, from your examination, if you were the umpire of this matter, you would make no change in the recommendations of the minority board except as to the lock nearest Panama?

Mr. STEVENS. And one other thing, Senator, which I think I have brought out. I would not start for two or three years to build the breakwater at Colon.

Senator GORMAN. Yes.

Mr. STEVENS. There are \$5,000,000 in that estimate that might possibly be saved. I would dig my channel, or enough of it to enable me to make an experiment through two or three stormy seasons; and if that channel remained open, or reasonably so, so that at moderate cost it could be kept open, I certainly would not throw the money into a breakwater.

Senator GORMAN. With those two exceptions you recommend that project?

Mr. STEVENS. I would recommend that project, and I will go further and say this—a man can not say any more—that if I had to build that canal with my own money, as between the two plans I should take the high-level plan, even if I expected that my family to come after me for generations would operate it.

Senator GORMAN. That is very clear.

The CHAIRMAN. It has been stated here within the last few months, Mr. Stevens, that political influences have existed in regard to the appointment of men on the Isthmus—perhaps before you came to the Isthmus, Mr. Stevens; possibly since. Have you any knowledge of any employees among your people there now who were appointed there through any political influence?

Mr. STEVENS. I have not. I can only speak directly for my own appointees, of course. There has not been an appointment that I know of, nor a man on my pay rolls, that has either been placed there through political influence or has retained his position through political influence, nor has there been any attempt on anyone's part to retain him through political influence.

The CHAIRMAN. I notice that in this article of Mr. Bigelow's, which has become somewhat celebrated, he speaks of certain parties being there from political influence. I think "Senatorial influence" was the expression he used. Do you know anything about that?

Mr. STEVENS. Well, I denied that over my signature very strongly. I could not put it any more strongly in the English language.

The CHAIRMAN. And you know nothing of anything of the kind?

Mr. STEVENS. I know nothing of anything of the kind. There is not the slightest thing in the world of that kind that I know of, and I would know it if there was anything like that.

(Mr. Stevens was thereupon excused, with the thanks of the committee; and the committee adjourned until Friday, January 26, 1906, at 10.30 o'clock a. m.)

STATEMENT OF WILLIAM H. BURR
BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Wednesday, March 7, 1906.

The committee met at 2 o'clock p. m.

Present: Senators Millard (chairman), Kittredge, Ankeny, Morgan, Taliaferro, and Simmons.

Present, also, Maj. Gen. George W. Davis, U. S. Army (retired).

STATEMENT OF WILLIAM H. BURR, ESQ.

Senator KITTREDGE. Mr. Burr, will you give your full name to the stenographer?

Mr. BURR. William H. Burr.

Senator KITTREDGE. And what is your age?

Mr. BURR. Fifty-four.

Senator KITTREDGE. Where do you live?

Mr. BURR. In the city of New York.

Senator KITTREDGE. What is your profession?

Mr. BURR. Civil engineer.

Senator KITTREDGE. What is your record from boyhood in that profession? State it to the committee in a general way, please, and with what great enterprises you have been connected.

Mr. BURR. I graduated from the old civil engineering school at Troy, N. Y.; the Rensselaer Polytechnic Institute, in 1872, and I have been in the continuous practice of my profession since that time. During the first ten years of my practice I was engaged chiefly in subordinate positions, as a young man, in iron bridge building and in city waterworks. From 1884 to 1891 I was engaged wholly in iron and steel bridge construction with the Phoenix Bridge Company, with works at Phoenixville, Pa., and with main offices at Philadelphia and New York; but since 1891 I have lived and carried on the practice of my profession wholly in the city of New York.

I should have stated that from 1875 to 1884 I was a member of the faculty of the institution from which I graduated, in addition to carrying on the active practice of my professional work; and it was at the close of that period that I made my connection with the Phoenix Bridge Company.

In 1892-93 I was professor of engineering at Harvard University. From 1893 to the present time I have occupied the chair of civil engineering in Columbia University. During all this period, however, I have also been actively engaged in the practice of my profession, and continuously from 1892 to the present time I have been connected as a consulting engineer, frequently in charge of work, with

the department of public works of New York City—the department of parks, the department of docks, and the department of bridges. At the present time I am a member of a board of consulting engineers for the board of water supply of that city, which is a board created to construct an additional water supply for the city of New York.

Senator KITTREDGE. Involving the expenditure of how much money?

Mr. BURR. About \$150,000,000, estimated expenditure. I have also, since 1892, been a member of a board of engineers appointed by President Cleveland to consider the feasibility of bridging the Hudson River at New York in one span of about 3,200 feet. I was subsequently appointed also by President Cleveland member of a board to locate and design a deep-water harbor and harbor of refuge on the coast of southern California.

I was a member of the Isthmian Canal Commission of 1899 and 1901, having been appointed by President McKinley.

Senator MORGAN. That was the first Walker Commission, was it—the Isthmian Canal Commission?

Mr. BURR. Yes; it was not the first Commission, however.

Senator MORGAN. It was the second Walker Commission?

Mr. BURR. It was the second Commission of which Admiral Walker was a member.

Senator MORGAN. The second one?

Mr. BURR. The second one; yes. I was also a member of the present Isthmian Canal Commission for a year, until the reorganization of that Commission nearly a year ago.

Senator MORGAN. When did that reorganization take place?

Mr. BURR. The members of the old Commission resigned on the 31st day of March.

Senator MORGAN. And did you resign?

Mr. BURR. I did.

Senator MORGAN. At whose request?

Mr. BURR. At the request of the Secretary of War. It had been understood for a month or more—perhaps two months—that the members of that Commission would present their resignations at any time when it was the desire of the Secretary of War that they should be presented.

Senator KITTREDGE. While a member of the Commission you have just mentioned what were your duties?

Mr. BURR. The duties were of a general character, covering—

Senator KITTREDGE. I refer to the fact, if it be a fact, that you were on the committee in charge of the engineering features of the canal?

Mr. BURR. I was a member of the engineering committee.

Senator KITTREDGE. What other members of the Commission were members of that committee?

Mr. BURR. Mr. Parsons and Mr. Grunsky, as I remember. I think that is correct. Is it not, General Davis?

General DAVIS. And the governor of the Canal Zone ex officio.

Mr. BURR. And the governor of the Canal Zone when that committee was present on the Isthmus.

Senator MORGAN. What committee is that?

Senator KITTREDGE. It was a committee of the Commission.

Senator MORGAN. The executive committee?

Senator KITTREDGE. The engineering committee, as I understand it. Is that right?

Mr. BURR. Yes, sir.

Senator MORGAN. The engineering committee of the Commission?

Mr. BURR. Yes. Perhaps I should explain that the Commission was divided, for purposes of administration and performing the work, into five committees, if I remember right, and the engineering committee was one. Those committees were expected, in rotation, to be upon the Isthmus, so that practically four members of the Commission would be almost continuously on the Isthmus, the governor of the Zone being a member of each committee as it visited the Isthmus.

Senator MORGAN. Was the governor of the Zone a member of the engineering committee?

Mr. BURR. When that committee was on the Isthmus he was a member of that committee.

Senator KITTREDGE. And the governor at that time was General Davis?

Mr. BURR. The governor at that time was General Davis.

Senator KITTREDGE. And afterwards, what has been your connection with the Panama Canal enterprise?

Mr. BURR. Since the reorganization of the Commission I have been a member of the Board of Consulting Engineers, which recently made its report.

Senator KITTREDGE. You were one of the members of the board that signed a report in favor of the construction of a sea-level canal?

Mr. BURR. I was.

Senator MORGAN. You are not now a Commissioner?

Mr. BURR. I have not been a Commissioner, Senator, for nearly a year.

Senator KITTREDGE. Are you familiar with the report that a minority of the Consulting Board of Engineers made, favoring the construction of a lock canal?

Mr. BURR. I am.

Senator KITTREDGE. Have you read the testimony of Mr. Stevens, at the present time the chief engineer of the canal?

Mr. BURR. I have read very nearly all his testimony. Before to-morrow I shall have read all of his testimony.

Senator KITTREDGE. Now, Mr. Burr, will you please tell us the reasons for the conclusion you reach, and the objections and criticisms, if any, you make upon the report made by the minority of the consulting engineers, as well as of the testimony of Mr. Stevens? You may state it in your own way, if you please.

Senator MORGAN. First state which report you agreed to sign.

Senator KITTREDGE. He has stated that, Senator.

Mr. BURR. I signed the report of the majority, favoring and recommending the construction of a sea-level canal.

That will necessitate my covering considerable ground, and I will be glad if any member of the committee will interrupt me at any time and ask any questions, because, as the matter presents itself to my mind, it may not be illuminating to those who listen. I shall first—

Senator MORGAN. Before you proceed to state that, let me ask this question: You concurred in the report as it was presented to the President?

Mr. BURR. The report of the majority.

Senator MORGAN. I say, the report that you signed?

Mr. BURR. I did—oh, yes; I concurred fully.

Senator MORGAN. Were all the reasons set out in that report that you think are material to support it?

Mr. BURR. Those are all the main reasons.

Senator MORGAN. I suggest, then, that inasmuch as that report is here and in writing, and everybody has seen it, and all that, Mr. Burr should address his attention to such additional matters as may be useful, in his opinion, to sustain that report; or, if he has changed his mind, such additional matter as may account for that change.

Senator KITTREDGE. I think, Senator, that perhaps it might be better to have him state in his own way the reasons for his conclusion.

Senator MORGAN. That was what I was trying to get at—whether he had already stated them in his own way in signing that report.

Mr. BURR. I concur entirely in that report.

Senator MORGAN. Yes.

Mr. BURR. Wholly so; and I am as strongly in favor of a sea-level canal at the present time as I ever have been. The more I reflect upon it, the more it seems to me that that plan is the one which the United States Government should adopt.

I am willing to proceed in any way the committee desires.

Senator MORGAN. It is a mere suggestion of mine. I do not suppose you want to rehearse all of the matters that are contained in the report of the majority which you signed. I did not suppose you did. They are all here, and written out in very admirable style, very exactly and very fully and completely, I suppose; but it occurred to me that after allowing Mr. Burr to say, as he has done, that that report represents his views on the subject, he should proceed to state any other reasons that he may choose to advance for the support of that report.

Senator KITTREDGE. I think, Senator, that he should be permitted, at least for a time, to state his conclusions in his own way; and I ask that it be done, unless there is objection.

Senator MORGAN. I will repeat that I assumed that he did state it in his own way when he signed that report. But go ahead; I will make no further suggestion about it.

Mr. BURR. My conclusion as to the type of the canal which should be adopted for the ship waterway across the Isthmus has been based on about six and a half years of continuous study and observation, largely on the ground. In the work of the first Isthmian Canal Commission, where it was the duty of that Commission to determine the most practicable and feasible route for a ship canal, it was the unanimous opinion of that Commission that for its purposes a lock canal should be recommended, and it was recommended. That recommendation was largely for the tentative purpose of making a comparison between the Nicaragua and the Panama routes. In order to make a proper comparison, a comparison which might be considered fair and reasonable, it was necessary to make it upon the basis of a lock plan for each, because it would not be practicable or feasible in any sense of the word to construct a sea-level canal on the Nicaragua route.

There were, however, members of the first Isthmian Canal Commission, including Mr. Morison, now dead, and myself, who were somewhat surprised to find, by such approximate estimates as we were then able to make, that the sea-level plan came so near being feasible. It was a subject of remark between Mr. Morison and myself on more occasions than one. But with the information then available and for the purposes of that Commission, a lock canal only was considered feasible, and all members of the Commission united in that expression, myself among them.

When, however, the present Commission was created, further investigations were made, very extensive investigations, which it was not practicable for the first Commission to undertake or to complete, in the progress of which it became clear to my mind at least that a sea-level canal was entirely feasible and practicable; that many of the objections which had been supposed to exist, insuperable objections, largely or entirely disappeared.

Senator MORGAN. Objections coming from whom?

Mr. BURR. Not from individuals, but objections based upon the physical conditions and the feasibility of doing the work required in the construction of the sea-level canal.

Senator MORGAN. They were objections, then, that were considered by the Commission?

Mr. BURR. Objections that were considered by the Commission, and which had been frequently mentioned by others.

Senator MORGAN. And stated in their report?

Mr. BURR. Partially stated in the report, and stated by others outside of the Commission who had discussed the general problem. For instance, the control of the Chagres in case of a sea-level canal was one of the great objections; and there were others of that nature.

Senator MORGAN. But the Commission considered objections to a sea-level route at that time when they went down there to make the investigation?

Mr. BURR. They considered objections to a sea-level route.

Senator MORGAN. That was when you were investigating the comparative merits of the two canals?

Mr. BURR. Yes; under the first Isthmian Canal Commission.

Senator MORGAN. Under the first Commission?

Mr. BURR. Yes.

Senator MORGAN. Were not those objections stated by the Commission in their report?

Mr. BURR. Not all of them, I think; some were—for instance, the period of time which it was supposed it would take. That time, however, I should say, in justice to myself, I never concurred in. The periods of construction which were assigned to the Panama and the Nicaragua routes were decided by a five-to-four vote, five voting that a period of twelve years should be assigned to the construction of the recommended lock plan on the Panama route and ten years for the construction of a lock canal on the Nicaragua route. I opposed that. I never believed that that length of time should be assigned for the construction of the Panama route, and I have never changed my judgment on that point.

Senator MORGAN. You thought it was too short?

Mr. BURR. I thought it was too long.

Senator MORGAN. On the Panama route?

Mr. BURR. Yes. I thought that twelve years for the construction of the Panama Canal as then proposed was too long; that it could be done in a shorter time.

Senator MORGAN. That was a lock canal?

Mr. BURR. That was a lock canal.

Senator MORGAN. How about the sea-level canal?

Mr. BURR. I believed that the time mentioned in that report—from fifteen to twenty years, if I recall it rightly—was too long.

Senator MORGAN. How much too long?

Mr. BURR. I believed so at that time.

Senator MORGAN. How much too long?

Mr. BURR. I was not at that time able to state how much too long, because our investigations were not sufficiently extended to enable a reasonable estimate of time to be made.

Senator MORGAN. But you all went far enough in your investigations to satisfy yourselves that you could make a report to the President that the sea-level canal was not practicable within the meaning of the act of Congress?

Mr. BURR. At that time and for the purposes of that Commission.

Senator MORGAN. Well, practically within the meaning of the act of Congress?

Mr. BURR. I should be entirely willing to subscribe to that form of answer, Senator, if it is to be understood that the meaning of the act of Congress had for its purpose the comparison of the two routes, but not as an absolute verdict as to the two types of canal.

Senator MORGAN. In other words, you did not consider yourself committed by signing that report—joining in it—to the proposition that a sea-level canal at Panama was impracticable?

Mr. BURR. Not necessarily. I felt—and I am sure at least one other member of the Commission also felt—that our investigations were not sufficiently extended; it was not possible at that time to extend them sufficiently to settle that question finally.

Senator KITTREDGE. Who was the other member of the Commission?

Mr. BURR. I refer to Mr. Morison.

Senator KITTREDGE. When did he die?

Mr. BURR. He has been dead about a year and a half.

Senator MORGAN. Did he write any on the subject before he went away?

Mr. BURR. Oh, yes; he wrote a good deal.

Senator MORGAN. On the practicability of a sea-level canal?

Mr. BURR. No; not on the practicability of the sea-level canal, but on the canal question in general.

Senator MORGAN. Oh, I know that; I have those writings; but I did not remember that he had ever passed his judgment in writing upon the practicability of a sea-level canal.

Mr. BURR. I do not think he did, sir.

Senator MORGAN. No; I think not. When did you first arrive at the conclusion that a sea-level canal was practicable?

Mr. BURR. I first arrived fully at that conclusion about a year ago—a little more than a year ago.

Senator KITTREDGE. You may proceed in your own way, Mr. Burr.

Mr. BURR. That conclusion was reached after our experimental

work and our engineering investigations in general, as carried out by the Isthmian Canal Commission as then constituted. We had made many surveys and investigations during the preceding months. We had operated experimentally a number of steam shovels and old French excavators under very disadvantageous and uneconomical conditions, which showed that the excavation could be made at materially less cost than was theretofore anticipated, and that a greater rate of progress could be made. So that a maturer study of the greatly extended information secured convinced me that a sea-level canal was entirely practicable and feasible.

Senator MORGAN. Before that time had you been convinced of that?

Mr. BURR. I had not been convinced until the additional information and data which I have described were available.

Senator SIMMONS. Was that before you were appointed on the Board of Consulting Engineers?

Mr. BURR. That was before; yes.

Senator MORGAN. Is the sea-level canal that you speak of and have in mind of the Bunau-Varilla type—the “straits” through there?

Mr. BURR. No, Senator. I think that is an ideal ultimate attainment, but not at all necessary for the greatest volume of traffic that will be needed, perhaps, for half a century or more, and not within the meaning of the law under which we were acting.

Senator MORGAN. We could accommodate the law to that if we had the money, could we not?

Mr. BURR. We could, I suppose.

Senator MORGAN. And if we wanted to take the risk. The plan, then, which you had in your mind, and to which you gave your full adherence a year ago, or about that time, was not a sea-level canal; it was a canal with a lock?

Mr. BURR. That is a sea-level canal, Senator.

Senator MORGAN. If it requires a lock wherein is it a sea-level canal?

Mr. BURR. Because the elevation of the water surface in the canal would be at mean sea level.

Senator MORGAN. But there would still be an elevation of the water to mean sea level?

Mr. BURR. I do not quite understand your question, sir.

Senator MORGAN. If I understood you, you said that the elevation of the water in the canal would be at mean sea level.

Mr. BURR. Yes; the water surface in a sea-level canal would be at mean sea level.

Senator MORGAN. It would require some lifting, would it not, to get it up from the actual sea level to the mean sea level?

Mr. BURR. It would in some stages of the tide, and it would require dropping down at others.

Senator MORGAN. Exactly; 20 feet oscillation between the points?

Mr. BURR. It would be 10 feet lift at extreme high tide, or 10½, and 10½ feet fall at extreme low tide.

Senator MORGAN. That is 20 feet?

Mr. BURR. Twenty-one.

Senator MORGAN. Twenty-one feet?

Mr. BURR. Yes.

Senator MORGAN. Then it would require a lock there, and lock gates, to get the water into the canal and out of the canal?

Mr. BURR. It probably would; but I am not at all certain that it may not be entirely feasible to enter and leave that canal without a tidal lock at the Panama end of the canal. But even if it should require such a lock, its gates would be wide open at least half the time.

Senator MORGAN. Well, "half the time" is a loss of half the time, is it not? If the gates are open half the time, it is a loss of half the time—the other half—is it not?

Mr. BURR. During the other half of the time the lock would be used.

Senator MORGAN. It would have to be used?

Mr. BURR. Yes.

Senator MORGAN. So the loss would be the time that would be necessary in getting in and out of it?

Mr. BURR. Yes; but it would be a sea-level canal even with that lock.

Senator MORGAN. It does not strike a man that knows nothing about engineering that it could be a sea-level canal if the water was compelled to be lifted 10 feet and let down 10 feet in order to get an actual level.

Mr. BURR. At extreme tides.

Senator MORGAN. At extreme tides. They come once a day, at least, do they not?

Mr. BURR. No; not such extreme tides—oh, no! They are only the extreme spring tides. They occur every lunar month.

Senator MORGAN. In the intervals between the spring tides, what is the average rise and fall of the tide there?

Mr. BURR. The mean range of tide, I think, is 13 or 14 feet. I think the mean range is about 14 feet.

Senator MORGAN. Yes.

Mr. BURR. The range at neap tides, the low tides, is, if I recollect right, about 7 or 8 feet only.

Senator MORGAN. Yes. range of 21 feet, are very rare. They do not occur even every lunar month, but—

Senator MORGAN. Both at a neap tide and at a spring tide, your view, as I understand it, is that locks and gates—lock gates—would be necessary?

Mr. BURR. At spring tides they would probably be necessary; but I say that it is not clear in my mind yet, I am not satisfied, that the entrance of the canal at the Panama end, where these high tides are found, can not be so devised as to do away with the lock. But in the absence of a demonstration we must assume that a tidal lock would be necessary, and we have so assumed it.

Senator MORGAN. Therefore you put a tidal lock into your estimate of the cost?

Mr. BURR. Yes.

Senator MORGAN. No matter what might be the effect?

Mr. BURR. Yes; we did.

Senator MORGAN. That is what I wanted to find out.

Senator KITTREDGE. Is that all for the present, Senator?

Senator MORGAN. That is all that I wish to ask him.

Senator KITTREDGE. Will you please now proceed, Mr. Burr?

Mr. BURR. One of the great objections to a sea-level canal, or one of the greatest alleged objections to a sea-level canal, heretofore, has been the assumed impracticability of controlling the floods of the Chagres River. The average rainfall on the Isthmus is about 130 inches—125 or 130 inches—on the Caribbean side.

Senator MORGAN. Per annum?

Mr. BURR. Per annum; and, approximately speaking, about half that on the Pacific side of the Isthmus. The watershed of the Chagres River lies on the Caribbean side, so that it receives this greater rainfall. Above Bohio the watershed of the Chagres River has been variously estimated at 700 to 800 square miles. The doubt as to the exact area arises from the fact that no complete surveys of that watershed have ever been made.

It is, therefore, not a large river. It is a small river. But the downfalls of rain are sometimes at such a high rate, and the watershed, the higher part of the watershed above Gamboa particularly, is such as to induce a very quick run-off; and that produces rapid rises or quick floods, reaching sometimes—it is supposed 70,000 to 80,000 cubic feet per second at Gamboa, or possibly 110,000 or 112,000 cubic feet per second at Bohio.

Senator MORGAN. Please give the measurements in feet.

Mr. BURR. The measurements of rise in the river?

Senator MORGAN. Yes.

Mr. BURR. I do not recall those accurately, Senator; but the highest flood, I think, means about 38 feet rise at Bohio, and about 32 feet at Gamboa. Those figures are not far out of the way.

Senator MORGAN. Those rises are sudden, are they not?

Mr. BURR. Those rises are sudden.

Senator MORGAN. And sometimes follow each other in rapid succession, with a few days' interval?

Mr. BURR. There has been a record of no more than two or possibly three (I think only two) successive rises; but it is a juncture which must be provided for.

Senator MORGAN. One of those records you speak of ran up to 45 or 47 feet, did it not?

Mr. BURR. I think not as high as that, Senator. I think that there is no rise higher than 38 feet at Bohio, although I am speaking from memory and may be mistaken to a slight extent.

Senator MORGAN. It is not very material anyway, I think. That is to be taken into account, as I understand you, in determining the question of the control of the waters of the Chagres River?

Mr. BURR. It has been found feasible to control those floods with absolute certainty, with as much certainty as ever attends the construction of any engineering work.

Senator MORGAN. You say "found feasible?"

Mr. BURR. Yes.

Senator MORGAN. By practical experiment?

Mr. BURR. No; by actual surveys and computations, the usual methods.

Senator MORGAN. After all, that is in a sense conjectural, is it not?

Mr. BURR. Oh, I think not, Senator. Enough works have already been constructed of precisely the same character as those which would be required for that purpose to, I think, demonstrate with certainty that they may be made there.

Senator MORGAN. But have they been in precisely such a country with respect to the rainfall, or with respect to the precipitation—I mean the sharpness of the elevation.

Mr. BURR. We have much greater rises in this country, Senator, than the rises in the Chagres River.

Senator MORGAN. In this country?

Mr. BURR. Yes.

Senator MORGAN. Have we any greater rainfall than comes there within a few weeks or a few days?

Mr. BURR. No; we probably have not as heavy rainfall, but we have rivers with much greater watersheds, so that the range between high and low water is almost double that of the Chagres.

Senator MORGAN. But the time of rising and falling is longer?

Mr. BURR. It is longer; yes.

Senator MORGAN. That has to be accounted for, has it not?

Mr. BURR. Not in the controlling works. That is, the rapidity of rise does not affect the difficulties of construction of the controlling works. We do not care how rapidly it rises, so far as they are concerned—that is, so far as their safety and their construction are concerned. It is only the maximum height which has to be provided for.

Senator SIMMONS. Mr. Burr, have you stated yet what length of time it took generally for these high rises?

Mr. BURR. No; I have not stated; but you may get on the Isthmus one of the highest of the freshets within about thirty-six hours—from thirty-six to forty-eight. Usually it is a little longer than that from the beginning of the flood, but you may say that the maximum flood may be attained in from thirty-six to forty-eight hours. But they are also of short duration, as might be expected in such a quick stream.

Senator MORGAN. Mr. Burr, in your conclusion as to the controllability of the waters of the Chagres, where would you put your controlling works?

Mr. BURR. I should put the controlling works at Gamboa. A dam would be built across the Chagres River at that point of sufficient height to raise the surface water in the lake to about 175 feet above sea level, or about 125 feet above the bed of the river at that point.

Senator MORGAN. The fall being 50 feet from there to sea level?

Mr. BURR. About 50 feet. The bed rock is found there at about sea level—that is, about 50 feet below the bed of the river, which is within easy reach of construction. It is an admirable place for a dam, and it is a wonder that the French company was so easily discouraged from building at that point.

Senator MORGAN. What is the character of the rock, if you please?

Mr. BURR. The rock, like all the rock in that country, is of volcanic origin.

Senator MORGAN. Basalt?

Mr. BURR. I do not think that at that point there is any basalt, although there is some not far from that. The hard rock at Gamboa is a peculiar rock, different from anything that we have here, and I do not know that I am enough of a geologist to describe it properly; but it is a hard, gritty rock.

Senator MORGAN. Tough?

Mr. BURR. Tough; most of it is. It has, of course, some soft portions.

Senator MORGAN. With dikes coming up through it?

Mr. BURR. No; not at that point.

Senator MORGAN. There are no dikes in the foundation rock at Gamboa?

Mr. BURR. No dikes; but it would undoubtedly be found of irregular quality, like all the rock in that vicinity.

Senator MORGAN. I understand.

Mr. BURR. The basalt dikes, strictly speaking, are about nine miles from there, near Pedro Miguel. There is columnar basalt there.

Senator MORGAN. You say you would put your controlling works at Gamboa; how would you take care of the waters that come in through the affluents of the Chagres River below Gamboa, between that point and Port Limon?

Mr. BURR. Those are all comparatively small, with the exception of the Gatun River, which now empties into the Chagres River at the little native village of Gatun. The discharge of that river would be carried to a part of the bay back of Colon called Puerto Escondido.

Senator MORGAN. You mean to the east of Colon?

Mr. BURR. To the east of Colon. That channel is largely constructed at the present time. It was partially completed by the old French Company. By that means the waters of the Gatun River, or Gatuncillo, as it is sometimes called, would be taken to the ocean without going into the canal at all. They would be kept out of it entirely.

Senator MORGAN. How about the other streams? I do not care about going into the particulars about it; I simply want to know how you take care of all of those streams.

Senator KITTREDGE. Senator, would you just as soon permit Mr. Burr to point to the map?

Senator MORGAN. Oh, I have no objection; of course not.

Mr. BURR. This partially completed channel is shown as running from Gatun, entirely easterly of the canal line, over into Puerto Escondido, which is at this point [indicating], Colon being here; so that the waters of the Gatun River will be carried to the sea without going into the canal at all. They will be entirely kept out.

Senator MORGAN. That would be done, I suppose, by constructing a dam near the canal?

Mr. BURR. There would be necessary a couple of small dams near Gatun so as to make a continuous channel for the river without running into the Chagres, as it does now.

Senator MORGAN. You would not turn the current of the Gatun River back upon itself, but you would divert it to this point you speak of?

Mr. BURR. I would divert it to the ocean in that way.

Senator MORGAN. Yes; divert it by means of a dam.

Mr. BURR. There are two or three of the small streams (what you may call the larger of the smaller streams, because they are all small) which run into the Chagres from the west, that is, from the left-hand side of the canal as we look at it from here—which would be turned back upon themselves, so to speak, by relatively small dams, so as to be turned back into other watersheds, and so carried down to the ocean also without going into the canal at all.

Senator MORGAN. They would pass over the crest of their watersheds into the sea on the other side?

Mr. BURR. Yes; they would not run directly into the sea, but into streams which run into the sea.

Senator MORGAN. I understand.

Mr. BURR. The still smaller streams—and there are quite a number of them, but all very small—would be taken directly into the volume of the canal in the ordinary way, quite an ordinary procedure in canal construction; but instead of pouring directly into the prism of the canal they would first pass through a basin built on one side of the canal prism, so that any sediment which they might bring down in floods would be held there and the water would flow over a weir into the canal. In that way no sediment whatever from the Chagres River or from any of its tributary streams would be brought into the canal. It would be entirely kept out, and it would also be kept out of the canal on the Pacific side from the small streams—because there are only small streams on that side—in a precisely similar way.

Senator MORGAN. So that the water would find its way into the canal, but the sediment would be left behind in these basins?

Mr. BURR. The sediment would be left behind in these basins.

Senator MORGAN. It would come in as clear water?

Mr. BURR. It would come in as practically clear water.

Senator MORGAN. But it would all go into the canal?

Mr. BURR. It would all go into the canal. The great Gamboa Lake would, of course, contain all the sediment of the Chagres above the Gamboa dam.

Senator MORGAN. That would be a good deal, would it not?

Mr. BURR. I think it would be a good deal. There is some doubt about the measurements that were made by the first Isthmian Canal Commission, of which I was a member, as to the amount of sediment which comes down the river past Alhajuela; but there would be considerable sediment.

Senator MORGAN. How would you dispose of that to prevent it filling up the basin?

Mr. BURR. It would take a very long period of years to fill up that great lake.

Senator MORGAN. Well, we expect to live a long time, you know—that is, this Government does.

Mr. BURR. Well, I suppose that after a century or a hundred and fifty or two hundred years some measures would perhaps have to be taken.

Mr. BURR. Dredging would relieve it. It would be very easy to pump it out onto the land, or even over a low divide, by hydraulic methods, such as are used at the present time, for a few cents a yard.

Senator MORGAN. Do you take that into your computation of the cost of the sea-level canal?

Mr. BURR. No; that is too far in the future, Senator.

Senator MORGAN. Too remote?

Mr. BURR. Too remote.

Senator MORGAN. Do you take in your computation the amount of water that you have to deal with, I will say, that comes from these affluents of the Chagres River below Gamboa into the channel of the canal?

Mr. BURR. We do. We take into account all the water that would be brought into the prism of the canal.

Senator MORGAN. As it all comes in, is it your opinion that in the highest flood waters that occur on the eastern or northern side of that Caribbean range of mountains there might not be a disturbance in the navigation of the canal?

Mr. BURR. No, sir; there is not enough to make any disturbance in the canal.

Senator MORGAN. Not enough to make any currents?

Mr. BURR. Not currents that would disturb navigation at all. There might be maximum currents of perhaps a mile and a half to a mile and three-quarters, possibly two miles an hour, at most, on some rare occasion. I should have stated, in speaking of these great floods, that they come rarely. There have been only five in about the last fifty years.

Senator MORGAN. A great steamer navigating that canal from the Bay of Limon, we will say, going south, or wherever it is—it is south—and encountering such floods as this in that part of the canal below Gamboa, would have to make some provision for resisting them, would it not?

Mr. BURR. No, sir; it would steam right through without any disturbance whatever.

Senator MORGAN. You think a current of a mile and a half an hour in the canal would not affect its navigation?

Mr. BURR. Not at all, nor considerably more than that. A current of 2 miles an hour would not disturb it.

Senator MORGAN. It would not disturb the navigation? It would be as safe in a mile-and-a-half current as it would in dead water?

Mr. BURR. Practically so. It has been found so in other canals. The Suez Canal sometimes has materially greater currents than that, and they have not been found to give any material inconvenience to navigation; and I think fully as great currents as that are found in the Manchester Canal. You know those are not matters of speculation or of opinion. They are simply matters of observation of such canals as the Suez and the Manchester.

Senator MORGAN. How would it be on the southern side of the canal when you were navigating a steamship 800 feet long and with a displacement of 15,000 tons or 20,000 tons, going toward Panama, if, in addition to the water coming from a flood in the Chagres, there should be also a spring tide meeting you, going out toward Panama? Would not that create a current?

Mr. BURR. That raises the question of the necessity or not of the locks in the extreme spring tides. Of course if the tidal lock were present, the influence of the extreme tides would be kept out of the canal.

Senator MORGAN. At sea level there would be practically solid rock on both sides of this canal for a distance of 10 or 12 miles, would there not?

Mr. BURR. Do you mean through the summit divide?

Senator MORGAN. Between Emperador and Culebra Heights.

Mr. BURR. Yes; there would be solid rock on both sides.

Senator MORGAN. Solid rock on both sides?

Mr. BURR. Yes.

Senator MORGAN. And some curvatures to pass?

Mr. BURR. Yes; some curvature; very easy curvature.

Senator MORGAN. Emphasis seems to be laid by some of the engineers upon the proposition that navigation through that part of the canal would be perilous, or would require very great caution, even under normal conditions of water supply; and that opinion seems to be intensified in respect to the situation that would be created by the incoming of waters from the Pacific or the outgoing of waters from the Pacific in combination with a flood in the Chagres.

Mr. BURR. The waters from the Chagres floods would only be permitted to enter the canal by the controlling works at such a rate as would not make a current of over a mile and a quarter an hour at most.

Senator MORGAN. But that current might go either way.

Mr. BURR. If the current goes both ways, if it were equally divided and should go both ways, it would be only half that.

Senator MORGAN. Yes.

Mr. BURR. So that even if it all goes one way, even if it went toward the Pacific, which is scarcely conceivable, there would be no current—experience shows that—which would be materially inconvenient to navigation.

Senator MORGAN. You say experience shows it. I suppose you have some model or plan which looks exactly like this?

Mr. BURR. No; we have more conclusive evidence than would be shown by a model. We have the evidence of the navigation of the Suez Canal, where the curvature is not so very different from that which would exist in the sea-level canal, and with a much narrower prism.

Senator MORGAN. It has not any rock walls on the sides of it, has it?

Mr. BURR. It makes no difference what the character of the banks are, if you have a sufficient cross section of water. The width of this canal between the solid rock banks would be 200 feet, and the actual width of the Suez Canal at the present time, even on the curves, is only 131 feet, and the width at the turning-out places, the passing places, is only 147½ feet. So that the width of the sea-level prism proposed is wider throughout the whole length of this proposed canal than even the passing places on the Suez Canal at the present time.

Senator MORGAN. Does your plan or your idea of a sea-level canal include turning-out places?

Mr. BURR. The whole canal is a turning-out place.

Senator MORGAN. Not for two big ships?

Mr. BURR. Two big ships could pass each other anywhere; but if it is desired to have more free passing places, turn-outs can be constructed anywhere at very small cost. But, as a matter of fact, with the actual experience of the Suez Canal before us, the whole canal is really a passing place, and all ordinary ships would pass each other anywhere.

Senator MORGAN. But what about extraordinary ones?

Mr. BURR. Extraordinary ships could pass anywhere in this 200-foot section, even the largest ships. It would only be in the Caribbean and Pacific ends where it would be necessary to provide even

a little additional width for passing places for the greatest ships that are now projected.

Senator MORGAN. Creating turn-outs, if they became necessary, in this great wall of rock cut of 10 or 12 miles—I do not know exactly the distance; nobody knows how long it would be—would be expensive; would it not?

Mr. BURR. Pardon me, Senator—in that portion where we have rock walls there would be no turn-outs, because the width there is 200 feet, and that would pass any ships which are now projected—not actually afloat, but which are projected.

Senator MORGAN. Would it not be extremely unsafe for two great steamers to undertake to pass each other in a channel not wider than 200 feet?

Mr. BURR. They would not attempt to pass each other at speed. One would tie up.

Senator MORGAN. Ah! Now we have it. Then it is necessary to tie up one ship until the other passes?

Mr. BURR. Yes.

Senator MORGAN. That is in your plan?

Mr. BURR. Yes; precisely as is done in the Suez Canal at the present time.

Senator MORGAN. That is at the expense of considerable loss of time, is it not?

Mr. BURR. Not much; very little—very little. In fact, it does not seem to me that the actual difference in time of passing a canal of either type on the Isthmus is anything of material consequence one way or the other. I believe that the sea-level canal would pass any ship quicker than a lock canal; but I do not think the difference in time is of much importance.

Senator MORGAN. Does your plan imply that the vessels will pass through the canal with their own steam and their own propellers, without the assistance of tugs?

Mr. BURR. Yes; they do that in the Suez Canal, which has a materially smaller prism.

Senator MORGAN. It is not an uncommon thing for vessels to get ashore in the Suez Canal, is it?

Mr. BURR. Yes; it is an uncommon thing, but they do it at times.

Senator MORGAN. Yes; they do it.

Senator SIMMONS. Mr. Burr, what would be the difference between the summit level of the Gamboa Lake and the sea-level canal?

Mr. BURR. The sea-level canal would be at sea level, and the highest surface of water in the Gamboa Lake would be about 170 feet above it.

Senator SIMMONS. Above it?

Mr. BURR. Yes.

Senator SIMMONS. How would you get that escape water into the canal?

Mr. BURR. That comes through regular controlling sluices in the dam, and then is carried down in a specially constructed masonry conduit with steps and other forms which are commonly used by engineers in such cases, so that when it reaches the level of the water in the canal—not in the canal, but in the basin on one side of it—its velocity is practically destroyed; so that it flows over a long weir

from that basin quietly into the canal. There is no cascade into the canal.

Senator SIMMONS. Where it enters the sea-level canal, the summit would be about how much above the level of the sea-level canal?

Mr. BURR. Practically the same thing; just enough to make it flow over a weir.

Senator SIMMONS. How far would the dam of that lake be located from the prism of the canal?

Mr. BURR. It is about a half a mile; about that. I have forgotten the exact distance, but it is practically half a mile.

Senator SIMMONS. By gradual steps you would let the water down that distance of half a mile to the level of the canal?

Mr. BURR. Yes; it would come down with its current baffled, as we say, by these various constructions, so that when it enters the canal it is a quiet sheet of water flowing over a weir.

Senator MORGAN. You put the sluices in the dam, do you?

Mr. BURR. In the dam.

Senator MORGAN. On the same principle as the dam at Assouan?

Mr. BURR. Very much the same.

Senator MORGAN. There are doors that can be lifted?

Mr. BURR. Yes.

Senator MORGAN. Do you consider that a safe method of handling the water?

Mr. BURR. It has been found so by prolonged experience. That is not a matter of conjecture. There are many such controlling methods constantly in use, and have been for years.

Senator MORGAN. There is no danger of obstruction from floating timbers, or anything of the kind?

Mr. BURR. Oh, there may be occasionally a small obstacle in working a gate, just as all devices are occasionally open to a little derangement; but nothing to give any material trouble.

Senator MORGAN. These sluice gates would pass directly through the cross section of the dam, would they?

Mr. BURR. In this case they would be put at the westerly end of the dam—about at the end of my pencil. The dam itself would be right across the Chagres River.

Senator SIMMONS. Mr. Burr, I understood you to say that you would go about 50 feet below the present land surface to get the foundation for that dam?

Mr. BURR. To bed rock.

Senator SIMMONS. Yes; to bed rock. Now, how high did you say that dam would be, starting at this foundation?

Mr. BURR. It would be a little under 200 feet in total height from its top to the bed rock. The surface of water in the lake would be about 170 feet above bed rock.

Senator SIMMONS. What would be the length of that dam?

Mr. BURR. The length of the dam is about 2,200 feet, if I remember right.

Senator SIMMONS. And what is its width at its base and at its summit?

Mr. BURR. The width at the base and at the summit would depend upon whether it is built as a masonry dam, or whether as an earth dam with a masonry core.

Senator SIMMONS. Which do you recommend?

Mr. BURR. I would favor an earth dam with a masonry core; but a concrete dam, all masonry, would be, perhaps, equally good. I say that I would favor an earth dam with a masonry core simply because a large amount of the waste of the Culebra cut could be deposited there very conveniently; but the estimate of the majority of the board covers the cost of that dam abundantly, whether it be made of concrete or of earth with a masonry core.

Senator MORGAN. Do you remember that estimate, in round numbers?

Mr. BURR. I think about \$6,000,000.

Senator SIMMONS. What would be the width at the bottom in that case?

Mr. BURR. In that case the width of the masonry core would be 50 feet.

Senator SIMMONS. At the bottom?

Mr. BURR. As we designed it for our estimates. The width of the great earth bank in which it is embedded would be as much as you please to make it. We estimated that it would be at least 2,000 feet, perhaps half a mile. Of course that is much more than is necessary for stability; but so long as the spoil must be deposited somewhere it could be deposited there so as to make this dam a part of the earth's surface, a great mountain across the valley.

Senator SIMMONS. Two thousand feet wide at the base?

Mr. BURR. Two thousand feet wide at the base, and at the top—I have forgotten, but I think it was possibly 200 feet. It might be more; with the waste that would have to go in somewhere, in fact, it would probably be ten or twelve hundred feet.

Senator SIMMONS. How high would that dam be above the mean level of the lake?

Mr. BURR. That would depend upon how low the surface would be drawn down. If it were to be drawn down 30 feet, or I will say 35 feet—I am speaking from memory—if it should be drawn down 35 feet that oscillation in the lake's surface would more than take care of two successive floods the greatest of which we have any record at the present time.

Senator SIMMONS. How high would it be? How much would it be above what you estimate would probably be the highest level of the lake?

Mr. BURR. I do not know that I quite catch your question, Senator; but let me put it in this way—that the highest water surface in the lake——

Senator SIMMONS. That is what I mean.

Mr. BURR. The highest water surface in the lake would be about 170 feet above mean sea level, and mean sea level, of course, would be the elevation of water surface in the canal. In other words, it would be about 170 feet above the surface of the water in the canal.

Senator MORGAN. When you speak of taking care of two successive floods, the largest that have occurred, do you mean without resort to the sluice gates?

Mr. BURR. There is volume enough to take two successive floods.

Senator MORGAN. Without running anything off through the sluice gates?

Mr. BURR. Without running anything off through the sluice gates.

Senator MORGAN. The length of those sluice gates, of course, would correspond with the width of the dam, which might be, you say, even half a mile?

Mr. BURR. No; pardon me. The sluice gates would not be as long as the dam. The sluice gates would occupy the western end of the dam.

Senator MORGAN. On the western side of the dam?

Mr. BURR. Yes; where there is rock in the hills, so that the gates themselves would be founded right in the rock, which reaches up nearly to the top of the dam at that end.

Senator MORGAN. Yes.

Mr. BURR. So that the overflow through those sluice gates could never imperil the stability of the earth part of the dam. You see, they are so far on one side and running down through natural rock and masonry channels that the safety of the earth part of the dam would be absolutely assured.

Senator MORGAN. So that there would be no sluice gates at all except through this extension of the dam, which is made for that purpose?

Mr. BURR. That is it, precisely.

Senator MORGAN. And a sluiceway dug out in this bed of rocks?

Mr. BURR. In the rocks.

Senator MORGAN. Out of the hills?

Mr. BURR. Yes.

Senator KITTREDGE. Is the foundation of the Gamboa dam the same, no matter which kind of dam is to be constructed?

Mr. BURR. It would be the same—that is, you would go down to bed rock in either case.

Senator KITTREDGE. Of what material would the foundation be constructed?

Mr. BURR. If it were of masonry it would be concrete only, because that is the most economical, and absolutely durable.

Senator SIMMONS. Mr. Burr, would not that dam cost very nearly if not quite as much as the large dam at Gatun that is proposed in connection with the lock-canal plan?

Mr. BURR. Very nearly, as the estimates are made; but at the proper time I shall do as I did in the board itself—criticise that design, and state why, in my judgment, it is not a proper construction for such an important work. If it were put into the condition which, in my judgment, the importance of the work demands, it would cost much more than it is estimated to cost.

Senator SIMMONS. And would that amount be much greater than the estimated cost of the dam at Gamboa?

Mr. BURR. It would be materially more; I can not state just how much.

Senator SIMMONS. According to the estimates of cost made by the engineers who recommended the lock canal, it would not be much greater than your estimate of the cost of the dam at Gamboa?

Mr. BURR. I will give you just the exact estimates, Senator, in one moment, if you will pardon me. The estimate of cost of the Gamboa

dam in the sea-level plan is \$6,000,000. The estimate for the Gamboa dam and spillway—that is a part of the dam, of course, just as much as the sluice gates of the other dam are—is \$7,788,000.

Senator MORGAN. A million and a half more at Gatun than Gamboa?

Mr. BURR. A million and three-quarters.

Senator TALIAFERRO. And you will contend that, properly constructed, that cost is underestimated?

Mr. BURR. That will be my criticism.

Senator SIMMONS. Can you give me, in that connection, the estimated cost of the dam that is to be constructed on the Pacific side—the large dam in connection with the other lock? I do not know what that other lock is called. What is it called?

Mr. BURR. Sosa lock, I think it is.

Senator SIMMONS. Sosa lock—yes.

Senator KITTREDGE. You mean the three dams?

Senator SIMMONS. Yes—well, all except the one that provides for the oscillation of the tides.

Mr. BURR. There are two dams, you know, Senator, on the Pacific end. There are two dams there. There is a hill called “Sosa Hill” right in the line of those two dams, and one dam is on one side of it and the other on the other.

Senator MORGAN. They are connected with an embankment?

Mr. BURR. Well, yes. The hill right in the low ground, called Sosa Hill, is connected by a dam with Ancon Hill on one side, and with the hill on the other side of the Rio Grande estuary also by a dam.

Senator KITTREDGE. Is there not a third dam, Mr. Burr, from Ancon Hill over toward the railroad?

Mr. BURR. There is a dyke there, yes; you may call it a dam. That is correct. It is not so high as the others. The La Boca dam—that is, the dam to the westerly of Sosa Hill—is estimated to cost \$1,675,000, and the Ancon-Sosa and Ancon-Corozal—that is the one which you have in mind—amounts to \$1,645,000 more. The total is \$3,320,000; and in my judgment the same criticism would be made, only stronger, if anything, against the sufficiency of those dams as against the sufficiency of the Gatun dam. But that is a matter which I will take up further on.

Senator KITTREDGE. Mr. Burr, is there not another dam and lock at Miraflores?

Mr. BURR. Not at Miraflores. There are approach walls to the Pedro Miguel lock which play almost the part of dams; but they are not called a dam. They are a part of the lock works.

Senator KITTREDGE. Have you the cost of the construction of them?

Mr. BURR. Of the Pedro Miguel locks?

Senator KITTREDGE. Yes; of the approaches to the Pedro Miguel locks.

Mr. BURR. The Pedro Miguel locks, including excavation and back filling, \$6,988,000, and approach walls, \$300,000, or about seven and a quarter millions—chiefly for the locks.

Senator KITTREDGE. That is at Pedro Miguel?

Mr. BURR. Yes.

Senator MORGAN. That corresponds, then, to the dam at Gatun?

Mr. BURR. Yes.

Senator MORGAN. Where is the additional cost of the Gatun dam project over the sea-level project as to dams on the Pacific side?

Mr. BURR. I do not know that I understand your point, Senator.

Senator MORGAN. There is a certain cost of constructing the dams on the sea-level plan on the Pacific side, the Panama side. There is first an estimated cost of constructing the Gatun dam.

Mr. BURR. Pardon me; there is no dam on either the Panama or the Colon end in the sea-level plan.

Senator MORGAN. Well, I call it a dam. I am speaking about the approaches into the ocean on either side.

Mr. BURR. Oh, do you mean the approach channel?

Senator MORGAN. Yes; the approach channel.

Mr. BURR. Those are costly works, because on the Panama end there is a large amount of rock excavation in those channels.

Senator MORGAN. And in addition to that there are the lock gates?

Mr. BURR. The lock, the tidal lock, which is also an expensive feature, costing, as I remember, about six millions, or estimated to cost about six millions; but I will give you that in a moment. Six millions is allowed for the twin tidal locks at the Panama end of the canal in the sea-level plan.

Senator MORGAN. Then when you get a ship through the twin locks it is in the Bay of Panama?

Mr. BURR. It is in the Bay of Panama.

Senator MORGAN. What cost is there for constructing the channel from that point out to those three islands there, which are the anchorage of the incoming ships?

Mr. BURR. From the end of the lock to deep water the estimated cost is \$6,196,000.

Senator MORGAN. Now we will turn over to the other side.

Mr. BURR. That is largely due to the rock excavation.

Senator MORGAN. Now we will turn over to the other side. What is the cost—

Senator KITTREDGE. May I ask a question before you put that?

Senator MORGAN. I would like to complete that question. It is a question consisting of two propositions.

Senator KITTREDGE. That is all right.

Senator MORGAN. The cost of making a ship channel in the Bay of Limon, as estimated by the minority of that Commission, and also of a breakwater, is that estimated for?

Mr. BURR. Yes; the breakwater.

Senator MORGAN. In the Bay of Limon?

Mr. BURR. It is practically the same. The sea-level estimate is \$5,000,000; the lock estimate, \$5,300,000. That is for the breakwaters. The channel in Limon Bay is \$624,400 in the sea-level plan and \$1,245,000 in the lock plan.

Senator MORGAN. Yes.

Mr. BURR. It is much wider.

Senator MORGAN. I merely wanted to get those figures associated together, so that they would be easy of comparison, you know. I want to get this proposition that we are discussing simplified, if we can do it, down to the question of the actual work of cutting the channel of the canal.

Senator KITTREDGE. The question that I wished to ask Mr. Burr is

if there is any material difference in the work in Panama Bay for one type of canal as compared with the other?

Mr. BURR. No; not in Panama Bay.

Senator KITTREDGE. It is just the same?

Mr. BURR. It is just the same.

Senator SIMMONS. Mr. Burr, you said a little while ago, as I understood you, that you disposed of the waters of the Gatun River by building a dam and providing a drain way, you say. You would have to do that, would you not?

Mr. BURR. Yes; we would have to complete that diversion channel, which is now partially dug.

Senator SIMMONS. You said there were some other small streams which flow naturally into the Chagres, which you would dam up and throw the waters back on themselves for the purpose of preventing sediment flowing into the prism of the canal.

Mr. BURR. Yes.

Senator SIMMONS. Could you tell what would be the cost of the construction of that dam and drain way to dispose of the waters of the Gatun River, and the cost of the dams of these other streams that would have to be dammed under the sea-level plan, but not under the lock plan?

Mr. BURR. About three and a half millions.

Senator MORGAN. That includes the Gatun River?

Mr. BURR. That includes the completion of the river diversions, the formation of dams across tributary streams, the regulation of the rivers which flow into the canal, etc.

Senator MORGAN. Now, except the Gatun River, all of those rivers which you would have to take care of there with these dams come in from the west?

Mr. BURR. They nearly all come in from the west.

Senator MORGAN. The Gatun River is the only one you would have to control?

Mr. BURR. Yes; the Gatun River is by far the largest. The most of those streams are very small. In fact, when I have been on the Isthmus in the dry season some of them were practically or absolutely dry—essentially so.

Senator SIMMONS. Now, Mr. Burr, summarizing, what would be the total difference as to the cost of constructing dams and drainways to dispose of the waters of these streams between the lock-canal plan and the sea-level canal plan? I am speaking merely now of dams and drainways to control these waters.

Mr. BURR. The total cost under the sea-level plan would be the three and a half millions which I have just mentioned, added to the six millions for the Gamboa dam, which would make nine and a half millions, to which the usual 20 per cent has been added. That is the total cost of all those works for the sea-level plan.

Senator SIMMONS. Both dams and otherwise?

Mr. BURR. Yes. In the lock plan there is no corresponding item, because all the rivers there flow into the lakes unobstructedly.

Senator SIMMONS. So that in the lock plan you only have the dams at Gatun and La Boca there?

Mr. BURR. Yes.

Senator SIMMONS. Those three over there?

Mr. BURR. Yes; those three over there and the Gatun dam.

Senator SIMMONS. Not the Gatun Lake; you mean the La Boca Lake?

Mr. BURR. I mean there are three dams on the Pacific side; those three smaller dams and the one Gatun dam on the Caribbean Sea.

Senator SIMMONS. And the Gatun dam, in connection with the lock-canal plan?

Mr. BURR. Yes.

Senator SIMMONS. And their cost is—

Mr. BURR. Their cost is \$3,320,000.

Senator KITTREDGE. That makes seven million and something.

Mr. BURR. Yes; and then there are diversion channels—four and a half millions added to \$7,800,000—say about twelve and a quarter millions.

Senator KITTREDGE. I do not quite understand that. Probably I am in error. The dam at Gatun costs seven million and a half?

Mr. BURR. About \$7,800,000.

Senator KITTREDGE. Yes. Then the three dams at La Boca and Sosa Hill—

Mr. BURR. And the diversion channels.

Senator KITTREDGE. And the diversion channels cost how much?

Mr. BURR. About four and a half millions more.

Senator KITTREDGE. Yes; I understand.

Mr. BURR. And to that sum would be added the usual 20 per cent.

Senator TALIAFERRO. What comparison are you making now, Mr. Burr?

Mr. BURR. I was simply answering the question as to the cost of these particular works; that is all.

The CHAIRMAN. I would suggest that it would be a good deal more expeditious if we let Mr. Burr go on and make a general statement of this thing, and then take up the questions afterwards.

Senator MORGAN. I think we are making very good progress.

Senator SIMMONS. The objection to that, to my mind, is that we lose the questions and lose the pertinency of them.

The CHAIRMAN. Of course you know that we will have all of that evidence that Mr. Burr gives us to-day before us in the morning; and I suppose you will be with us to-morrow, anyway, Mr. Burr. I simply thought it would expedite matters a little; that was all.

Senator MORGAN. I think every question that has been asked has been material.

The CHAIRMAN. I think so; I have no doubt of that, Senator; but I was thinking whether we could not proceed a little faster; that was all.

Senator KITTREDGE. You may proceed, I think, Mr. Burr.

Mr. BURR. The other feature of the construction of the sea-level canal which has been considered of great difficulty is that of the excavation through the summit cut. The total length of the canal between 42-foot contours is about 49 miles. Of that distance about 25 miles, perhaps 18 on the Caribbean side and 7 on the Pacific side is through a territory the surface of which is but little above sea level, so that the canal throughout those portions would naturally be a sea-level waterway.

The remaining 24 miles, or about 24 miles, approximately, from Bohio to Miraflores, is of a different character. It embraces the high ground along the canal line, the highest of which is at Culebra, the summit of the Cordillera at that location. That summit originally was about 330 feet above sea level. It has now been cut down about 160 or 165 feet. The bulk of this excavation, involving the greatest difficulty and requiring the most time, is located along about 8 miles of this distance, from Obispo, near Gamboa, to Pedro Miguel. The total volume of excavation within that distance is about 110,000,000 cubic yards.

The surface is clay, and it is in that surface clay where the difficulty of slipping or sliding has been encountered, although that difficulty has been much exaggerated. When clay is wet it will slip, whether it is in this country or on the Isthmus. That feature of this work does not seem to me to be so formidable as it does to many, because from my student days in Troy down to the present time I have seen a great deal of wet clay. I have seen it slip. I have been brought in contact with it many times.

The vicinity of Troy, N. Y., is one of clay hills. There have been many slips there, one of which occurred in my student days on the line of the New York Central road, between Troy and Schenectady, in a cut, as I recall it, between 40 and 50 feet deep. The bank slipped on one side of that cut and filled in, so that railroad traffic was interrupted for perhaps ten days. There have been numerous slips within the limits of the city of Troy on the steep hills about there, all due to water getting into the clay. All that is necessary to remedy such a condition is simply to excavate the clay or to drain it and keep the water out; and that is all that is necessary in the great Culebra cut.

It is not a new problem. It is no formidable feature of the work. It has simply to be treated down on the Isthmus precisely as it is treated here. There would be no slipping of the clay in the vicinity of the Culebra cut if it is drained, as it may be, or if portions of it, where it may readily be treated in that way, are excavated. It is not a material difficulty; it is not an obstacle to the construction of a sea-level canal. It simply means drainage and excavation; that is all. I might say that I speak, perhaps, with undue emphasis on this point, because I have been over every foot of that ground myself, and in view of my previous experience with slipping clay, which I have just stated, I speak not from hearsay or opinion, but from actual observation extending over many years.

Below this surface of clay there is found the characteristic rock and indurated clay of the Culebra cut. The upper part, or nearly all of the upper part, of the cutting below this surface clay is a peculiar indurated clay, within which, however, are found veins or strata of hard basaltic rock; not a clear basalt, but hard rock of a basaltic nature—very hard rock. All of this material, whether the indurated clay or the hard rock, must be blasted, the softer part of it requiring but small charges of black powder, others being hard enough to require dynamite; but it is a material which presents no special difficulty in excavation. It has simply to be attacked like any other rock excavation, soft rock or hard rock, as the case may be.

Senator ANKENY. What do you mean by indurated clay? What is it stated to be in the books?

Mr. BURR. It is called indurated clay in the books. It is a peculiar material.

Senator ANKENY. Is it a clay at all?

Mr. BURR. Yes; it is a clayey material, but it shades off into the surface clay that I have already spoken of on the one side and down into hard rock on the other. It is difficult for one who has been accustomed to seeing only the materials here in this country to realize what irregular and unusual stuff you may find on the Isthmus. I know it impressed me in that way.

Senator ANKENY. I did not mean to interrupt you.

Senator MORGAN. This clay is supposed to be disintegrated rock, is it not?

Mr. BURR. It is supposed to be, and undoubtedly it is. Much of this hard or indurated material which I speak of, all of it so hard as to require blasting, will go to pieces if you put a lump of it in a glass of water; it will go to pieces within a few seconds.

Senator MORGAN. It dissolves, like sugar or salt or something of that kind?

Mr. BURR. No; it does not dissolve. It simply goes to pieces and falls down into fine material; and yet you may sink a pit in that material, and the pit will fill with water and stay there apparently indefinitely.

Senator ANKENY. Will it deliquesce, or gather moisture?

Mr. BURR. No, sir; it does not. I have been down in those pits myself that have had water in them for months, and the sides——

Senator ANKENY. I mean will it absorb moisture in a damp climate, so that it would fall away, as camphor does, for instance?

Mr. BURR. No, sir; it weathers a very little, but not much. These banks have stood up there for six years, within my personal experience, and the weathering has been very little; very little, indeed; surprisingly little.

The excavation of this cut, which has been regarded with so much apprehension, I might almost say with dread, and which still appears to be regarded in that way in some quarters, seems to me to be without any of those awe-inspiring features. It is a plain case of digging. The only unusual feature about it is its size; that is all, absolutely. There is nothing else about it that is out of the ordinary. It is simply an enormous piece of excavation. You can, as we of the consulting board have done, lay out a system of attacking that cut, much as it was laid out by the New Panama Canal Company, with a programme to be carried out with as much certainty as ever can be attached to any great engineering work. In fact, it is very seldom that a great engineering work offers so clear and unobstructed a programme for execution as the taking out of the material in that cut.

The particular part of the cut which each shovel will excavate, and from which tracks or to which tracks must be led can be set forth with mathematical precision; so that the actual progress of the work can be conclusively demonstrated. If you put a steam shovel against a face of material of this kind, and put steam on it, it will work; and if you have tracks leading up to it, and locomotives with cars on them, you can certainly get the material away at a rate which can be estimated. It is perfectly practicable. It does not seem to me

that the simplest procedures within the range of engineering construction involve such great uncertainty. In fact, in my judgment, they involve no uncertainty at all. We know that during the rainy season there will be some interruption to work, although I am satisfied that that interruption is not nearly so great as many suppose it will be, for I have been on the Isthmus during the rainy season as well as the dry season. I have been there when it rained heavily.

The CHAIRMAN. Mr. Burr, just for my own satisfaction, I want to ask you this: When we were on the way to Panama you told me the amount of rainfall that was had at Greytown. To satisfy my curiosity on that point, I want you to state what that is.

Mr. BURR. About 25 feet, Senator.

The CHAIRMAN. In a year?

Mr. BURR. Yes, sir. Fortunately, we have not that to contend with on the Isthmus.

The CHAIRMAN. It was so much that I was very much surprised, I know.

Mr. BURR. That is not every year, but it is not phenomenal.

The CHAIRMAN. Proceed. Excuse me for interrupting you.

Mr. BURR. It seems to me, therefore, that if there is any one part of this work which is freed from the usual uncertainties of engineering construction it is this plain, simple matter of digging this great mass. And I want to say, right at this point, that that is not any new impression of mine. It is precisely the impression that I had when I was on the Isthmus between five and six years ago, and which prompted me to argue obstinately for the assignment of a shorter period of construction for the Panama Canal than for the Nicaragua.

My mind was absolutely open in going there, but I have been forced by the results of my observation to these conclusions. So that, when you lay out the detailed plan of attack for the excavation in the Culebra cut and make all allowances for rainy weather and for inefficiency of labor, which is great on the Isthmus, for the liabilities to breakdowns of steam shovels or for any other material delays, and allow an ample margin for exigencies which can not be anticipated, I believe there is nothing more certain in estimating the rate of progress of any great work than the time which the majority assigned for the completion of this summit excavation.

I have not the slightest doubt that that entire excavation can be completed within ten years. When I make that statement I appreciate fully its gravity and what it means. I have been face to face with the situation on the ground many times. I have watched the excavation many times. I have endeavored to realize all the uncertainties which are usually assigned to it, but, as an engineer who has had some experience with large works, I can not see where these dreadful difficulties exist that are supposed to attend the excavation of this great cut. I think that the lions which are so often seen in the way—which have been seen and are still seen—are due to its magnitude only.

It is a work which requires patience first, and patience last, and patience all the while between; but all it needs is that persistence which, constantly exerted, will accomplish any work on schedule

time. It is easily feasible to drain the work so that the water falling upon it in the heaviest rains will run off quickly. The work in no case need then be delayed more than a few hours, except possibly in the case of an occasional slip, which will occur rarely.

We have heard a good deal about the rains rendering the tracks unusable. As a matter of fact the tracks of the Panama Railroad have been there for fifty years, and I do not know that the total delay from wetting those tracks and washing them away is enough to be assigned. Bridges have been carried away occasionally, of course; but it is perfectly feasible, within the range of any competent engineer's capacity, to construct those surface tracks that lead up to the shovels in such a way that there will be no sensible break in their operation due to the rainfall. It will require a little more substantial construction of tracks than those which ordinarily lead to a railroad excavation while it is in progress of construction, but that is not material.

The ballasting will have to be done with a little more care, and drainage will have to be completed in a perfect system leading to every elevation of track throughout the whole cutting; but that is perfectly feasible. A considerable number of those tracks and of considerable length will be permanent. They will be used throughout the entire work. Those would be ballasted like any railroad track. All those matters are feasible; they are simple matters of everyday construction with an engineer.

Senator ANKENY. That applies to all of your laterals, does it?

Mr. BURR. Yes. It applies to all laterals, and there would be tracks on the different terraces very near where the final slopes would exist that would be used for years for carrying away this material. Those tracks would be ballasted in a permanent way, like any railroad track. The additional cost is not much.

The whole rational question resolves itself simply into making a proper preparation for this work. That is all there is of it. There is nothing extraordinary, nothing unusual; but it does require great patience and persistence—that is, you have got to do a great deal of work over a period of perhaps two or three years that does not appear to bring any adequate return, but it will bring its return. In fact, it will bring about the completion of the excavation.

As stated in the report, it is practically a matter of demonstration that that material can be excavated from the summit within the period of ten years. If we add to that 25 per cent additional time, after making all the other allowances which have been made, as the board did, giving a period of from twelve to thirteen years, it is an outside limit of the time for the completion of the canal. I believe that it can be done and will be done.

Senator ANKENY. With either type?

Mr. BURR. In less time.

Senator ANKENY. With either type of canal—lock or sea-level?

Mr. BURR. I am speaking now of the sea-level plan. The lock plan I shall refer to to-morrow, assuming that we will not get to it to-day. It is a somewhat different proposition, but not altogether so.

Senator ANKENY. I did not mean to interrupt.

Mr. BURR. I am speaking now of this great Culebra cut, which has been such a bugbear to so many people. Its whole significance lies

in its size, that is all. It is not a complicated thing. It is a matter of transportation. The digging is a very simple matter. Transporting the material away is the essence of the whole problem, and the manner of attack which I have spoken of and which has been laid out with so much detail and so much care, is devised with a view to solving the transportation problem, not the problem of digging, because that takes care of itself.

Senator MORGAN. You cut through the Culebra Heights in benches?

Mr. BURR. Yes, sir.

Senator MORGAN. About what is the height of each bench?

Mr. BURR. Twenty-five or 30 feet. In the plan which I laid out for myself particularly I took them at 30 feet. In the scheme which Mr. Wallace laid out he took them at 25.

Senator MORGAN. What is the width of those benches?

Mr. BURR. Twenty-five feet.

Senator MORGAN. Twenty-five feet high and 25 feet wide?

Mr. BURR. I took the benches at 30 feet high and 25 feet wide. Mr. Wallace took them just the other way. But it does not make any essential difference. I took them at 25 feet wide because that is just the width required for the double track, which will allow the steam shovel on one track to be served by cars on the other; but 30 feet may be taken, so far as that matter is concerned.

Senator MORGAN. While you are running along with the cars on a bench 30 feet high, or 25 feet high, your shovels would work below?

Mr. BURR. No; the shovel will be at work on the same level.

Senator MORGAN. But it will work below and lift the material up to the cars, would it not?

Mr. BURR. No; the cars serving the steam shovel would be on the same level as the steam shovel itself.

Senator MORGAN. And work right against the wall?

Mr. BURR. Work right alongside of the steam shovel.

Senator MORGAN. Yes; on that line?

Mr. BURR. Yes, sir.

Senator MORGAN. When you get through with that you would go down and open another line?

Mr. BURR. Another steam shovel would do that after the upper one had gone far enough on to be out of its way.

Senator MORGAN. And you could keep up the work continuously if you had shovels enough?

Mr. BURR. Yes, sir; so that we could work at least 100 shovels. That can be demonstrated beyond any doubt whatever. But from 80 to 100 shovels is all that is necessary to accomplish this purpose.

Senator MORGAN. Why could you not carry the Panama Railroad on one of those benches through that divide?

Mr. BURR. It could be carried there eventually; but you would not want it running through the cut while the work was going on, because it would be in the way, that is all.

Senator MORGAN. Would it necessarily be in the way?

Mr. BURR. Yes; of course while you are at work on the cut you do not want anything more in there than you have to have.

Senator MORGAN. The difficulty I am trying to get rid of is one that has embarrassed me all the time, and I have not found anybody yet that could explain it fully. When this canal is completed,

whether it is a sea-level or a lock canal, that railroad has got to be changed from its present location, because it now crosses the canal twice.

Mr. BURR. Yes.

Senator MORGAN. Therefore, to prevent the crossing of the river but once, which would be at Gamboa, it must go up on the right bank of the Chagres, straight up to Gamboa, and from that out by Obispo, and from that out through, as I contend, the Culebra Heights. My proposition, or suggestion, rather, is that that railroad can be conducted or located there permanently and conducted on one of those benches so as to save winding around that hill and crossing this canal.

Mr. BURR. It can be. There is no question about that?

Senator MORGAN. It can be done now?

Mr. BURR. Only that it would be in the way of the work going on; that is all. But it could stay where it is until the canal is finished, and then you could change it.

Senator MORGAN. You think it would not do to finish it in that manner when you had got down below it, as you would be away down below it?

Mr. BURR. Yes; you can change it then if you desire to.

Senator MORGAN. Selecting a bench that is out of the way?

Mr. BURR. Yes, sir.

Senator MORGAN. And putting the railroad right through that cut, and keeping it on the right bank of the Chagres River all the way up until you crossed it at Gamboa?

Mr. BURR. That is feasible.

Senator MORGAN. That is the point I wanted to get at and to get on the record. That applies, I think, to both forms of canal?

Mr. BURR. I can not see that it makes any difference whether it is one type or the other.

Senator MORGAN. With a lake created by a dam at Gatun, you could not go anywhere else except on the right bank of the Chagres?

Mr. BURR. You would have, of course, to relocate the railroad. There would be no help for that.

Senator MORGAN. The whole length of it, down to Gatun?

Mr. BURR. Yes.

Senator MORGAN. That is what I thought.

Senator KITTREDGE. Within what time can the Culebra cut, in your judgment, be excavated?

Mr. BURR. Within ten years.

Senator MORGAN. Forty feet below sea level?

Mr. BURR. Yes, sir.

Senator KITTREDGE. Beginning at what time?

Mr. BURR. I mean ten years from the actual beginning of work.

Senator KITTREDGE. Can all the other works necessary to construct and complete a sea-level canal be completed within that ten years?

Mr. BURR. They can, easily.

Senator KITTREDGE. In other words, the time employed in the excavation of the Culebra cut is the maximum time for the completion of a sea-level canal; is that it?

Mr. BURR. That is the controlling feature, so to speak; yes.

Senator KITTREDGE. Under the type and plans proposed by the Board of Consulting Engineers—in other words, a sea-level canal—

is there involved any untried, unusual, or doubtful engineering proposition?

Mr. BURR. I know of none.

Senator KITTREDGE. And you make us that statement upon the years of experience you have mentioned?

Mr. BURR. I do.

Senator MORGAN. I wanted to ask you in that connection where you would put your dump in making a sea-level canal?

Mr. BURR. That is an open question. I think, now, that it would be a judicious disposition of that spoil to fill up all the marsh land, beginning at about Miraflores and extending to the mouth of the Rio Grande estuary. There are a considerable number of square miles of territory which at present is waste, and never can be anything else, in its present condition, but which could be filled and made valuable land by the spoil from the Culebra cut. It may be that it would be found advisable to carry some of it to sea and dump it. While I should not wish to commit myself absolutely to any plan of disposition at this moment, that is a perfectly feasible and reasonable plan.

Senator MORGAN. Can you take the spoil from Obispo, for instance, and carry it now to those flats out at the mouth of the Rio Grande?

Mr. BURR. I would, unless there was some convenient disposition for that at Obispo in the other direction. North of Obispo the amount of excavation is relatively small.

Senator MORGAN. Yes

Mr. BURR. That is, much less than the bulk of it in the other direction.

Senator SIMMONS. What will be the relative length of time required for the passage of a ship through a sea-level and a lock canal?

Mr. BURR. That will depend on the size of the ship. It is generally accepted and is confirmed by experience that if the area of wet cross-section of a canal prism is four times that of the immersed cross-section of a ship, the ship may pass through that canal at a speed of not less than 6 miles per hour. The section proposed in the sea-level plan fulfills that condition for all the great ships, or practically all now completed. It would not quite apply to the 800-foot steamships which are now being built or understood to be being built for the Cunard Line: but very near it. It even very nearly meets that condition for that size of ships. But I think that there is no ship now projected or likely to be built within the near future which could not pass through the canal at a speed of 4 to 5 miles per hour.

Senator SIMMONS. You are speaking of a sea-level canal?

Mr. BURR. I am speaking of the sea-level prism as proposed. But if it were the case of a battle ship, when it was urgent for the United States Government, for instance, to pass a fleet from one side to the other, I do not doubt that those ships would go through the prism as proposed from 6 to 8 miles per hour—that is, they would put them through at that speed. Of course if that were kept up day after day, eventually there would be perhaps a washing of the banks at some parts; but to meet an emergency, there would be no objection to such a procedure.

The most of the ships, however, which would go through that canal, the great bulk of them, up to sizes exceeding any ships that are now engaged in the South American trade, or even in the oriental trade,

would go through that canal at a speed of 6 to 8 miles an hour; and small ships, of course, at a greater speed.

Senator SIMMONS. Mr. Burr, you only spoke about the length of time it would require a ship to pass through the sea-level canal. Will you now please explain as to the lock canal?

Mr. BURR. The time required to pass through the lock canal is a matter of estimation. It is maintained by the minority that the largest ships could pass through the lock canal quicker than through the sea-level canal; but they admit that that would not be the case with the smaller ships, or possibly the bulk of vessels which would go through the canal. I doubt the accuracy of that estimate myself; and I doubt it for reasons which I shall give in detail when we get to that type of canal. With either type of canal, however, a ship can get through quickly enough for any demand of commerce. It has always seemed to me that any small difference—and the difference is only small—between the time of passage with either one type or another, is of entirely secondary importance, whether a ship goes through an hour quicker than another or not, except, possibly, in the case of a fleet in time of emergency.

Senator SIMMONS. You mean to say, then, taking into consideration the loss of time at the locks, that the difference in time required would not be very great?

Mr. BURR. It would not be very great. I believe, as a broad statement, that the ships would go through the sea-level canal more quickly than they would through the lock canal, but the difference would be small and of no special consequence.

Senator MORGAN. Mr. Burr, the two plans as laid down or described in the reports here start the canal, whether it be a sea-level canal or a lock canal, in the Bay of Limon, not at Colon.

Mr. BURR. The Board was unanimous, I think, that the best entrance is to go straight in from the Bay of Limon, instead of going around that curved entrance, although that curved entrance leads to an inner harbor of great value and would always be used as a harbor.

Senator MORGAN. I understand that. That is not to be thrown away. One is to be for the accommodation of commerce and for the Panama country and the other for the canal purposes exclusively.

In digging the sea-level canal between Gamboa and the Bay of Limon you would enter toward the east and would work toward the south?

Mr. BURR. Yes.

Senator MORGAN. And you would expect to do a large part of that with dredges?

Mr. BURR. Yes, sir; it could be attacked at various points.

Senator MORGAN. I know it could be, but the dredging work would be the cheapest?

Mr. BURR. Yes, sir. But I mean you could attack it at various points with dredges, even. You would not be limited to one end to work in.

Senator MORGAN. You mean you would use the waters of the Chagres River for floating the dredges?

Mr. BURR. Yes; and the partially completed canal. There is about 13 or 14 miles of partially completed canal.

Senator MORGAN. That reaches up to Bohio, does it not?

Mr. BURR. Practically to Bohio—not quite.

Senator MORGAN. You would run your dredges in those channels and get the water from the Chagres River or wherever you found it, necessary to float them?

Mr. BURR. Yes. It is Chagres water entirely.

Senator MORGAN. And when you came to the bed of the Chagres River you would keep right along in the bed of the river, dredging that out, on up toward Bohio?

Mr. BURR. I would.

Senator MORGAN. Would it be necessary to divert the Chagres River in order to work those dredges successfully?

Mr. BURR. Not at all.

Senator MORGAN. You would expect to take the river course, if it was coincident with the canal line, and work right on as if the river was not there?

Mr. BURR. Yes, sir.

Senator MORGAN. Preferring that it should be there?

Mr. BURR. Yes, sir; it is an advantage to have it there.

Senator MORGAN. I say, preferring that it should be there?

Mr. BURR. Yes, sir.

Senator MORGAN. The dump from those dredges, I suppose, would be disposed of in these marshy places there?

Mr. BURR. It would be disposed of in those marshes.

Senator MORGAN. And in these dumps did you propose to divert these smaller streams?

Mr. BURR. A little of it would be used there; but it would take a very small volume to do that; and the probability is that not much of the excavation from the canal prism would be used for such a purpose. It would be practically all waste. That near Colon would be used to fill up the town of Colon.

Senator MORGAN. Then, you would not find it necessary, if I understand it—and I think that is a very important inquiry—you would not find it necessary to build the dam at Gamboa until you had dredged up to the vicinity of Obispo?

Mr. BURR. I would not wait for that. The dam at Gamboa should be commenced at once.

Senator MORGAN. Very good; but you would not find any necessity for it in the matter of conducting the work until you had dredged up to the vicinity of Obispo?

Mr. BURR. It would not be necessary, but there would be advantages in building it at the earliest practicable date.

Senator MORGAN. What would they be?

Mr. BURR. In the first place, it would give you power.

Senator MORGAN. Oh.

Mr. BURR. And the quicker you complete that dam the sooner you will control the floods of the Chagres; and it would be better to have a uniform, moderate flow of the Chagres River when you are at work along it than to have the floods.

Senator MORGAN. In the matter of construction of the dam, both to the south of Gamboa and to the north of it, you would use the water of the Chagres River for floating the dredges, and you would use the railway from the heights there to haul your dump in, and you would want to put your dam there the first thing you did, or the core of it, and cover it in with this dump?

Mr. BURR. Yes, sir.

Senator MORGAN. Is that the method you have in mind?

Mr. BURR. That would be a very natural procedure, but there are many advantages in having that dam built as quickly as it is feasible to build it.

Senator MORGAN. So that would be one of the first works to be started?

Mr. BURR. Yes, sir; or should be.

Senator MORGAN. And when you got it so that it would hold water and all that you would commence dumping into it?

Mr. BURR. I would. In fact, I should not wait until then. I should commence dumping just as soon as the state of the masonry core wall, if it is built that way, would permit.

Senator MORGAN. And the spoil would come from the direction of Culebra?

Mr. BURR. The spoil would come from that direction. I must necessarily speak of this conditionally, because the chief engineer might find that he could get material close by, not from the canal prism, which he could dump into this dam to make its mass cheaper than he could bring spoil from Culebra.

Senator MORGAN. The other point I want to get at was this, in regard to the present situation of the work: Are you working steam shovels on both sides? Take the Culebra cut there as the center; do you work out with steam shovels in the direction of the Pacific and also in the direction of the Atlantic?

Mr. BURR. No, sir. There has been no excavation as such from the Culebra cut, unless it has been done very lately, for several months. In October when we were there, there was no excavation being made. The shovels were practically idle. There was a little excavation being made for the purpose of laying some tracks, but the experimental shovel work which was begun a year and a half ago was abandoned last July, and no excavation has been resumed since, as I understand it, unless it has been done very lately.

Senator MORGAN. Where is the dump or spoil bank of the work that has been done there before?

Mr. BURR. There are several of them, Senator. There are three main spoil banks—one called the Larejo spoil bank, which is at a marsh about, I should say, a mile from the center of the Culebra cut, or three-quarters of a mile—

Senator MORGAN. North or south?

Mr. BURR. Northeast; or I do not know but it is more nearly north, is it not, General?

General DAVIS. It is about north-northeast. It is the head of the Obispo.

Mr. BURR. Both the old and the new Panama Canal companies used that for a long time. Then there is a small dump which was used—about half a mile, I suppose, from the deepest part of the Culebra cut, on the other side of the railroad track—but that is a very small one. Then quite a large volume of waste material has been carried to a dump or dumps toward the Pacific in the Rio Grande Valley, within half a mile of the southern end of the Culebra cut.

Senator MORGAN. On that side of the work you work with shovels as well as you do on the north side?

Mr. BURR. You would, after the work was begun, naturally work with shovels on the north end as well as the south end.

Senator MORGAN. You would approach——

Mr. BURR. You would approach the two faces.

Senator MORGAN. And work in both directions?

Mr. BURR. And work in both directions.

Senator MORGAN. That is all I want to know about it.

Senator KITTREDGE. I suggest that we take an adjournment until to-morrow morning, Mr. Chairman.

(The committee thereupon adjourned until to-morrow, Thursday, March 8, 1906, at 10.30 o'clock a. m.)

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Thursday, March 8, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Ankeny, Morgan, and Taliaferro.

STATEMENT OF WILLIAM H. BURR, ESQ.—Continued.

Senator KITTREDGE. Mr. Burr, before you leave the subject that you were presenting to us yesterday afternoon I would like to have your views upon the question of unit prices adopted by the Commission and by the minority, if you please.

Mr. BURR. The unit prices used in both the majority and minority reports were fixed by the Board as a whole—that is, they were concurred in by both the majority and the minority.

Senator MORGAN. For all classes of work?

Mr. BURR. For all classes of work.

Senator MORGAN. Dredging and blasting and digging and all?

Mr. BURR. The whole of it; everything.

Senator MORGAN. And hauling?

Mr. BURR. Every item of that statement was concurred in by the entire Board.

Senator MORGAN. Very good. So that you had no trouble about applying the unit to the work?

Mr. BURR. None whatever. There were differences of opinion in the Board. I believe that some of those unit prices are too high, and I so stated when we were discussing that matter; but I concurred in the schedule as being the best that could be arrived at under the circumstances, and believed that any errors involved in their use would be on the safe side—that is, that they would make the work apparently cost more than in my judgment it actually will cost in construction.

Senator TALIAFERRO. The Board undertook, however, Mr. Burr, to arrive as nearly as possible at the exact cost of this work upon which they agreed on the unit prices?

Mr. BURR. They did. The work was referred to a special committee, and of course every member of the Board also took great interest in it and gave it a careful study. It was a piece of work that was done with the most earnest attempt to ascertain prices which would truly represent the cost of the various classes of material and

work involved. Such results are always more or less of a compromise in a body of nine men.

Senator KITTREDGE. There were thirteen men in this Board.

Mr. BURR. I should have said thirteen. I had the number of the old Commission in mind instead of the new Board.

Senator MORGAN. I would like to ask you a question right there. In applying these unit prices, upon which you all agreed for the work to be done, you then ascertained, I suppose, the cubic measurement of what you considered to be the different varieties of work that would have to be done—for instance, rock work, earth work, and dredging?

Mr. BURR. We did—with great care.

Senator MORGAN. You did not preserve the data laid before the Commission as to those estimates of the different varieties of work which was required to be done?

Mr. BURR. No; not the details of all the quantities which many of the individual members of the Board used. We have the details of the main computations.

Senator MORGAN. Did you disagree in regard to the main computations? For instance, as to the amount of dredging, the amount of rock work, and the amount of earth work.

Mr. BURR. Not to any material extent.

Senator MORGAN. You agreed pretty harmoniously upon those computations?

Mr. BURR. Yes.

Senator MORGAN. And as to how much of each kind of work would have to be done?

Mr. BURR. We did.

Senator MORGAN. I merely wanted to know about that. In arriving at those estimates did you take the French surveys and the French borings as a basis or the American?

Mr. BURR. Our main data were those obtained from American engineers and the results of American surveys. We, however, gave weight to all the information which we had, including the results of surveys and borings and other similar investigations made by the French companies; but our main data were those which have been obtained under the American régime.

Senator MORGAN. In ascertaining what was below the surface, of course it is conceded that you had to rely upon borings more than upon anything else?

Mr. BURR. You may say practically all the borings were made since the American occupation and by American engineers.

Senator MORGAN. Do you consider, now, that those borings were altogether sufficient to enable you to form a correct judgment as to the different varieties of work that you would have to do, and the quantities of it that would have to be done?

Mr. BURR. For all practical purposes.

Senator MORGAN. They are reliable?

Mr. BURR. They are reliable.

I want to speak for a moment about one item, as it has been criticised in different quarters, and that is the cost of removing rock under water, and the cost of all material below the elevation of plus 10, in the Culebra cut.

Senator KITTREDGE. What do you mean by "plus 10?"

Mr. BURR. Plus 10 means 10 feet above mean sea level.

Senator MORGAN. Above mean sea level?

Mr. BURR. Yes. Plus 10 means that.

Senator MORGAN. That is the highest range of the spring tides?

Mr. BURR. No, Senator. This has no reference to the range of spring tides.

Senator MORGAN. Yes.

Mr. BURR. It was an arbitrary elevation below which it was the judgment of the Board that the work would cost more than that above it.

Senator MORGAN. Yes.

Senator TALIAFERRO. In arriving at the mean level, you take into consideration the extremes of the tides, do you not?

Mr. BURR. Yes; we did, in fixing that datum. The mean sea level is the same on both sides of the Isthmus, and it is the mean between extreme high and extreme low water.

Senator TALIAFERRO. Yes.

Mr. BURR. The cost of rock removed under water at \$2.50 a cubic yard conforms well with the general range of prices for that class of work in this country. There are improved means of taking rock out under water which may and probably will reduce that unit cost. That was one of the unit costs which, in my mind, was taken too high; but I concurred in the judgment of the Board, and I stand by it.

At the present time there is a large contract in progress involving the excavation of about 2,000,000 cubic yards of hard sandstone rock, I think, in the St. Marys River, which is being done at \$1.36 per cubic yard. That is, it is rock under water, strictly speaking, but the contractor is taking it out by putting a dam across the St. Marys River above and below the location of the rock, unwatering the inclosure, and actually taking the rock out in the dry. But when the contract was awarded it was rock under water, and its cost is \$1.36 per cubic yard.

Rock is being taken out under water in Europe at the present time with what is known as the Lobnitz chisel, which is a great steel bar with one end sharpened in the form of a chisel, weighing 15 or 20 tons, perhaps, for from 50 to 70 cents per cubic yard, where the cost of labor is much less than it is in this country. The Lobnitz chisel has been used to some extent in this country, but has not so far been found a commercial success, although I believe that is due not to any lack of excellence in the method, but probably to lack of proper management of the work. However that may be, \$2.50 per cubic yard is certainly a most generous price for the removal of rock under water on the Isthmus. I believe it can be done for materially less than that.

The other item which has been criticised is the unit price of \$1.25 per yard for all material below the elevation of plus 10, or a plane 10 feet above mean tide in the Culebra cut. That price was agreed to by the entire Board. It was not a majority price; it was not a minority price; it was a price fixed upon by the entire Board, and it was done in view of the possibility of taking out some rock under water in the lowest part of the cut below sea level, and in view of the further fact that the rock near the bottom of the cut is harder, as a whole, than that above it. It was the judgment of the Board that

the difficulties which would arise below that plane were such as would justify that price and would be covered by it, while the price of the excavation above plus 10 is 80 cents per cubic yard. I have no idea that any rock in the lower part of the Culebra cut will ever be taken out under water. I know of no reason to suppose that it will be.

Senator KITTREDGE. Why?

Mr. BURR. Because contractors in this country and everywhere else pump out such pits or deep excavations, if any water gets into them, and do the work in the dry, which is much cheaper and much quicker. It is a constant practice, and I know of no reason to suppose that there would be any troublesome amount of water in the bottom of that excavation. There would be some doubtless, but—

Senator KITTREDGE. Are conditions in the Culebra cut favorable for doing work in that manner?

Mr. BURR. They are. They are very favorable; and, further, the price of \$1.25 is, to a certain degree, a combination of the \$2.50 price and the 80-cent price.

(By request of Senator Morgan, the stenographer read a preceding statement of Mr. Burr's, as follows:)

"I have no idea that any rock in the lower part of the Culebra cut would ever be taken out under water. I know of no reason to suppose that it will be."

Senator MORGAN. You mean be taken out while water is upon it?

Mr. BURR. I mean the water would be pumped out in the usual way.

Senator MORGAN. Yes.

Mr. BURR. And the rock excavated in the dry; the ordinary procedure under such circumstances.

Senator MORGAN. It would be practically dry work?

Mr. BURR. Yes, sir.

Senator TALIAFERRO. Is not 80 cents for the work in the Culebra cut above plus ten a very generous estimate—a liberal estimate?

Mr. BURR. Yes. That was one of the unit prices which I specially contended was too high. I believe it to be so. The experience which has accumulated on the Isthmus since the American occupation in the use of our steam shovels under the most disadvantageous circumstances of poor equipment, poor tracks, and with all conditions against them, shows that the price of taking out that hard rock has been as low as a little above 40 cents. I think that 80 cents a yard is too high. So that the estimated cost of that part of the work, for both plans, whatever the plan may be, is certainly generous.

Senator TALIAFERRO. My recollection is that Mr. Stevens estimated that amount at 60 cents. I do not recall certainly.

Senator KITTREDGE. Was it not Mr. Wallace that said that? I do not remember.

Senator TALIAFERRO. Was it Mr. Wallace?

Senator MORGAN. I have to go to the Senate, Mr. Chairman, as it is 11 o'clock.

Senator TALIAFERRO. I have to go to a committee meeting, Mr. Chairman, and if Professor Burr has reached a point where he can just as well stop, I move that the committee take a recess until 11.30.

(The committee thereupon took a recess until 11.30 a. m., at the expiration of which the hearing was continued.)

Senator KITTREDGE. Had you completed what you desired to say upon the question of prices when we took the recess?

Mr. BURR. That was all that I wished to say in answer to your question.

Senator KITTREDGE. Had you some questions that you wished to ask, Senator Morgan?

Senator MORGAN. I have some questions that I want to ask Mr. Burr.

I want to ask you a question, Mr. Burr, to remove a perplexity that is in my mind about the way of doing this work on the sea-level plan. That plan contemplates a depth of 40 feet below sea level for the prism of the canal?

Mr. BURR. It does.

Senator MORGAN. And a very considerable part of the length of the canal will pass through a mountainous region, probably 18 miles long—or a hilly region, I will call it?

Mr. BURR. Somewhat more than that.

Senator MORGAN. High ridges?

Mr. BURR. The higher ground—not all mountainous—but the higher ground of the entire line covers about 24 miles, from Bohio to Miraflores.

Senator MORGAN. In that, of course, there will be springs of water as you dig down. You will uncover springs of water?

Mr. BURR. Probably; as one usually does.

Senator MORGAN. You have done it already?

Mr. BURR. To a slight extent only in the Culebra cut, so far as it is now excavated; but undoubtedly the usual features of deeper excavation would be disclosed.

Senator MORGAN. And you will have to contend with the water that will find its way into the bottom of the canal from a rainfall of 25 feet a year?

Mr. BURR. Oh, no, sir. The rainfall of 25 feet a year pertains to Greytown, fortunately, and not to Colon.

Senator MORGAN. About what would it be?

Mr. BURR. Well, on the Caribbean side it is about 125 or 130 inches per year, and on the Panama side about half of that. At Culebra it has some intermediate value between those two.

Senator MORGAN. About how many feet a year?

Mr. BURR. I suppose in the Culebra cut, or in the vicinity of Culebra, the average rainfall averages somewhere around 100 inches, or 8½ feet. Perhaps General Davis can correct me on that.

General DAVIS. It is about 90 inches at Culebra.

Senator MORGAN. This canal prism is carried to the level of 40 feet below sea level?

Mr. BURR. Uniformly.

Senator MORGAN. I can not understand how you are going to keep the sea water from the Bay of Panama out of the canal while you are digging it 40 feet below mean sea level, if you open your diggings in the Bay of Panama and your dredging, or whatever it is, in the Bay of Panama and advance toward the Culebra Heights. What project or plan is there for keeping the sea water out of those diggings while you are conducting them down to 40 feet below sea level?

Mr. BURR. As I stated yesterday, in the low portions of the line, between Colon and Bohio, for instance, and between La Boca or the

tidal lock at Sosa Hill and Miraflores the presence of water is advantageous, because it floats dredges which can be used in taking out all the soft material over those portions of the line.

Senator MORGAN. I understand that.

Mr. BURR. And there is little else but soft material between Bohio and Colon. Between Miraflores and the deep water on the Panama side there is a large amount of rock to be taken out. That hard rock may be excavated in a number of different ways, which would be found most advisable when the work is done. That is, it may be blasted under water and taken out by dredge in the ordinary way, which would probably be the method to be pursued in the approach channel in Panama Bay; and between Sosa Hill and Miraflores it is probable that a portion of the rock would be taken out in the same way, and that other portions would be taken out by building a dam on either side, a great cofferdam, unwatering that and taking the rock out in the dry, just as MacArthur Brothers are now doing in St. Marys River, at \$1.36 a yard, while we have allowed \$2.50 a yard; or there may be other methods which it would be found advisable to follow as the work progresses. That covers the low grounds on either end of the canal.

Senator MORGAN. Up to Miraflores on the Pacific side and up to, we will say, Obispo on the other side?

Mr. BURR. No; not to Obispo, but Bohio.

Senator MORGAN. To Bohio?

Mr. BURR. Yes; on the Caribbean side.

Senator MORGAN. Very good.

Mr. BURR. Between Bohio and Obispo, or Bohio and the Culebra cut—because that is where the Culebra cut begins—there is a variety of material. Some of it might be taken out by dredges, and a large portion of it would undoubtedly be taken out by steam shovels, all in the dry. The rock—because there is a considerable quantity of rock between Bohio and Obispo—would be taken out probably by making great cofferdams, if necessary, or wherever necessary, for the deeper portions of those cuts, the Chagres waters meantime being carried entirely out of the present channel of the river in diversion channels, which I think are shown on this map here. Yes; they are shown as mere lines along here on one side of the Chagres channel [indicating on map].

Senator MORGAN. By “in the meantime” do you mean while you are constructing the work?

Mr. BURR. Yes; while we are constructing that portion of the canal prism; and they are provided for in the estimate. That would cover all the line from Bohio to Obispo. From Obispo to Pedro Miguel or Miraflores we have the great Culebra cut that we have already talked about. There would be a short portion at the southerly end of the Culebra cut between that and Miraflores, a very short portion, where the conditions would be such that the earth on the top of the rock would be taken out by steam shovels, and the rock below would be taken out probably by building small cofferdams or some other similar process; but all of the rock below sea level, if it is taken out under water, is covered by the \$2.50 cubic yard price, which is sufficient for the most difficult part of the work whatever it may be.

I do not believe myself that much rock between Miraflores and Obispo would be taken out under water. I think it would be taken

out by blasting and excavating in the dry in the ordinary method. That is the usual procedure, and I see no reason whatever why it should not be done there. Such water as finds its way into the pits would be pumped out.

Senator MORGAN. In approaching the elevation which you marked from Obispo to Miraflores as being the Culebra cut—in approaching that elevation on the Panama side or from the Caribbean side, you would approach with dredges?

Mr. BURR. You would approach with dredges up to Bohio.

Senator MORGAN. Up to Bohio on one side and up to Miraflores on the other?

Mr. BURR. Yes, sir.

Senator MORGAN. Very good. Now, you would be down 40 feet below sea level with those dredges?

Mr. BURR. Yes, sir.

Senator MORGAN. The ocean would follow you in?

Mr. BURR. We should want it to for those portions of the line.

Senator MORGAN. As a matter of course. Now, when you go to pump out your intermediate pits, I will call them, or diggings, how are you going to keep that ocean water out?

Mr. BURR. By dams, in the usual way. It is an ordinary procedure, constantly resorted to by engineers and contractors. It would be kept out precisely as MacArthur Brothers are now keeping out the waters of St. Marys River from that stretch of channel a mile or two long or more. I have forgotten how much it is.

Senator MORGAN. Can you keep it out so as to make the work you are doing in these deep cuttings practically dry work?

Mr. BURR. Yes, sir; practically dry work.

Senator MORGAN. All the way through?

Mr. BURR. Yes, sir; there is no unusual difficulty presented.

Senator MORGAN. Are all the arrangements or machinery, dams and cofferdams, and the like, such as you have mentioned, and many other things which you have not mentioned now because you can not anticipate what will be needed—are all those taken into consideration in the estimate of \$2.50 per cubic yard that you have mentioned for the digging?

Mr. BURR. They are. They are taken into account in every unit price which covers that part of the work.

Senator MORGAN. So that we can regard the \$2.50 a cubic yard as the maximum cost of all the work that is to be done in carrying this canal down to 40 feet below sea level?

Mr. BURR. You can; and it is a very generous estimate, in my judgment.

Senator MORGAN. I did not have it clear in my mind, and I wanted to get it on the record in clear form.

Senator TALIAFERRO. That is, that \$2.50 applies merely to the rock work?

Mr. BURR. To rock work under water.

Senator TALIAFERRO. To rock work under water?

Mr. BURR. It applies to rock taken out under water.

Senator TALIAFERRO. The Senator's question was general, and the record may make it appear that the \$2.50 is the maximum price of the total work between the points he named instead of the rock work under water.

Mr. BURR. It is the maximum unit price per cubic yard of all grades of work that will be done there.

Senator TALIAFERRO. The maximum unit price?

Mr. BURR. The maximum unit price. It applies to rock under water, which is the most expensive work that will have to be done.

Senator MORGAN. And this great Commission of which you are a member concluded that \$2.50 a cubic yard was a liberal estimate for the cost of all the work, whether dry or wet—that is, for all the hardest work, the most expensive work?

Mr. BURR. It decided upon that as a unit price for the most expensive work; yes.

Senator MORGAN. And the entire Commission agreed on that?

Mr. BURR. The entire Commission agreed on that unit price; yes, sir. If rock is to be taken out in the dry, where it is not under water, then the unit price is \$1.50 per cubic yard.

Senator KITTREDGE. That is, the maximum unit price?

Mr. BURR. It is a little confusing to use the word "maximum." Two dollars and fifty cents is the maximum of all the unit prices contemplated in this work. There is nothing higher than that.

Senator KITTREDGE. Yes.

Mr. BURR. And that covers rock under water. If that same rock is taken out in lock pits, in the dry, below elevation minus 10, it is \$1.50 per cubic yard. If it is taken out in the dry, without being below minus 10, except in Culebra cut, it is only \$1.15, and so on.

Senator TALIAFERRO. And the shovel work? Just continuing the estimates, you might include the shovel work in your answer.

Mr. BURR. The shovel work for earth in the dry, except in Culebra, is 40 cents per cubic yard. In Culebra it is 80 cents per cubic yard, because that means the hardened clay, or rock in process of decomposition, which has not yet become soft, or, on the other hand, if it is clay that is being hardened, that has not yet become a hard rock.

Senator TALIAFERRO. So that these estimates run from 40 cents per cubic yard for the easiest shovel work to \$2.50 for the most difficult rock work under water?

Mr. BURR. Yes, sir; that is it.

Senator KITTREDGE. Now, Mr. Burr, will you please give us your views about the lock plan, as proposed by the minority of the consulting board?

Mr. BURR. The lock plan, I assume, is familiar to all the members of the committee, as including a summit level of 85 feet above mean tide from Gatun to Pedro Miguel, where one lock of about 28 or 29 feet lift, if I remember right, brings the water down to the level of Lake Sosa, with a flight of two locks in series at Sosa Hill bringing the level down to mean tide in the Bay of Panama.

Senator KITTREDGE. You mentioned an elevation of 80 feet. Is it not 85 feet?

Mr. BURR. I intended to say 85 feet. If I said 80 feet, I intended to say 85. That summit level is maintained at the Caribbean end by the great earth dam at Gatun and by the lock at Pedro Miguel at the other end. There are three dams, comparatively short, one on either side of Sosa Hill and one between Ancon Hill and Corozal, the elevation of the surface of the water in Sosa Lake being 55 feet, if I remember correctly, above mean tide.

Perhaps the most prominent feature of the plan is the earth dam at Gatun, with the flight of locks of three in series in that structure.

There are some features of the construction of that dam which, while not being absolutely new, make it an untried structure under such circumstances as those found at its location. They are features which I have already criticised to the Board, and I shall state my objections, if it is agreeable to the committee, at this time.

The CHAIRMAN. That is what we want, sir.

Mr. BURR. The project of a dam at Gatun is a very old one. In fact, it was first broached at the International Scientific Congress held at Paris in 1879, and has been broached at various times since, but never seriously considered as a desirable part of a canal project until the considerations of the minority brought it into its present shape. As you are aware, the deepest bed rock found on the line of the dam is 258 feet below sea level.

Senator MORGAN. At Gatun?

Mr. BURR. Yes; at Gatun.

Senator KITTREDGE. Mr. Stevens, in his testimony, as I recollect it, stated that the deepest point to solid rock was 204 feet. Is he in error in that regard?

Mr. BURR. He must be in error. I think that that must be an oversight, because 258 feet, as I remember, is the exact result of the borings. Is not that so, General?

General DAVIS. Yes. They are reported by one of Mr. Stevens's assistants.

Mr. BURR. Yes; they are reported by Mr. Maltby, one of Mr. Stevens's assistants. I am not in error in the recollection that it is 258 feet. That is the actual depth.

Senator KITTREDGE. And the records so show it?

Mr. BURR. Yes, sir; and the records so show it. If Mr. Stevens mentioned 204 feet I think that must have been an oversight; 258 feet is certainly correct. I was looking at the section this morning, and I am inclined to think that that figure is shown on a profile in the minority report. If the committee will pardon me a moment, it will not take more than a moment to verify that.

General DAVIS. It is on plate 12.

Mr. BURR (referring to map). It is 258 feet—that is, the actual figure is not given, but it is more than 250 feet, and carrying out the proportion would make it 8 feet more, or 258 feet. I am very glad that that point has been brought up.

The subsurface material penetrated by these borings, which were made to a considerable extent—all the later ones—at the request of the Consulting Board, is shown on the profile to disclose the variety of materials which we find all up and down the Chagres River as overlying the bed rock.

Senator KITTREDGE. Is there a map with us showing the character of the borings?

Mr. BURR. This profile shows it, with one exception, which I will mention in a moment. You will see that various classes of material are exhibited—clay, clay and sand and sandy clay and gravelly material. The material is of varied character, and it is exceedingly irregular, as is shown not only by those borings, but by the numerous other borings, for hundreds of them have been made all along the Chagres, particularly at Bohio, at Buena Vista, at

San Pablo, and all the way up to Gamboa, even. There appears to be actual confusion in the way in which those finer portions of material, such as sand and clay and gravel, have been deposited along the geological valley of that river.

Senator KITTREDGE. What do you mean by the geological valley?

Mr. BURR. I mean the valley that would appear if all the fine material—clay, sand, and gravel—above the bed rock were taken out of the valley of the Chagres; the remaining irregular channel along the surface of the bed rock is what we call the geological valley of the river. That has been gradually filled up during ages, until the surface has reached its present elevation.

Senator KITTREDGE. In making these borings, Mr. Burr, did any water appear at the surface?

Mr. BURR. It did, sir, in a number of those borings.

Senator KITTREDGE. Is it shown on this map?

Mr. BURR. It is not shown on that map, and I presume it is through some oversight. It is a very important detail of that examination, and should be shown. The water appeared and flowed slowly over the top of the pipe—that is, with a head of a quarter of an inch or half an inch or three-quarters, as it might be, at various depths, from 32 feet down to nearly 258 feet, showing that permeable material is likely to be found at practically any depth below the surface.

Senator KITTREDGE. Beginning how close at the surface?

Mr. BURR. Thirty-two feet, as shown by those borings. If other borings were made, you would probably find places where it would appear nearer the surface.

Senator KITTREDGE. Did you have before you—and by you I mean the Consulting Board—maps showing the flow of water to which you have just referred?

Mr. BURR. We did. Not all of those borings which showed water, but some of them were made at the request of the Consulting Board. As fast as borings were made and the data secured, the results were cabled to the Commission and the Commission gave them to the Board, so that the profile was made showing the portions of the borings within which the water appeared. The latter by some oversight have been left off.

Senator KITTREDGE. What do you call that map? It is marked here "Plate 12." What map will show the water conditions you have just mentioned?

Mr. BURR. It is the profile of the Gatundam, by Mr. Maltby, who is the assistant engineer who did the work, dated November 3, 1905.

Senator KITTREDGE. Is that map in Washington?

Mr. BURR. That map is at the office of the Commission, and is available.

Senator KITTREDGE. Mr. Chairman, I move that that map be required to be brought here.

The CHAIRMAN. I supposed there was such a map in that package of maps. But I understand it is not there?

Mr. BURR. No; it is not there. The plate before you is the one that should show the information.

Senator KITTREDGE. And it does not show any of the indications that you have mentioned at all?

Mr. BURR. Not at all.

Senator KITTREDGE. I wish, Mr. Chairman, that that map could be brought before the committee forthwith, so that we could have it for use in connection with Mr. Burr's testimony.

(A telephonic message was sent to the Commission to furnish the committee with the map referred to.)

Senator KITTREDGE. Excuse me for interrupting you, Mr. Burr. Proceed.

Mr. BURR. The fact that the water flowed gently from the tops of these pipes used in making the borings shows that the river water was in communication with the material penetrated by the pipes. If it had been artesian water—that is, water which had flowed through the earth, through crevices in the rock, or in any other way from some distant and higher ground, as in the case of artesian wells—it would have come out of the pipe with a much higher head, as it ordinarily does with such wells; but it simply flowed over the top of the pipe, not far from the elevation of the water in the river.

Senator MORGAN. You say "not far from the elevation of the water in the river." You mean not far above the elevation?

Mr. BURR. Not far above the surface of the water in the river, I mean.

That same result has been seen time and time again in connection with our borings at the Bohio site and above. Some of the borings would not show any water flowing out of the top of the pipe and other borings would show them. There is nothing new about that. It is a rather ordinary feature of our usual experience in boring at that site; but it shows conclusively that the material penetrated by the pipe is permeable, and that water from the river enters it.

Senator KITTREDGE. Will it interrupt you if I ask you a question, Mr. Burr?

Mr. BURR. Not at all.

Senator KITTREDGE. Mr. Stevens, in his testimony, said that the material through which these borings were made was impermeable.

Mr. BURR. I know he says so.

Senator KITTREDGE. Have you any statement to make about that?

Mr. BURR. Yes.

Senator MORGAN. I hardly think that is an entirely accurate statement as to what Mr. Stevens said.

Senator KITTREDGE. I have forgotten exactly what he said.

Senator MORGAN. He said that, as a rule, it was impermeable; but he did not deny that there might be pockets or places where it was not.

Senator KITTREDGE. I will change my question. I think Mr. Burr has in mind perhaps what Mr. Stevens said. You have read Mr. Stevens's testimony?

Mr. BURR. Not all of it yet.

Senator KITTREDGE. Have you read the part of his testimony relating to that subject?

Mr. BURR. No; I have not.

Senator KITTREDGE. Then I will withdraw the question, temporarily.

Mr. BURR. I have understood that he made that statement, however. But that is a mere understanding.

There is, however, this statement in the report of the minority, and I think it must be due to an oversight: "In the upper 200 feet

some of the later borings show fine sand, while other borings near by show clay at the same depths, indicating, as do previous borings, that the upper 200 feet is practically impervious material."

Senator MORGAN. That is what Mr. Stevens said: "Practically," not absolutely.

Mr. BURR. The results of these borings which show water coming up through this material from depths of 32 feet all the way down to 258 feet are directly at variance with this statement. Of course water could not appear if the material were impermeable. The fact that water does flow through it and into the pipes and out of the tops of these pipes is, of course, conclusive evidence that it is permeable. I think that that must be due to an oversight.

Further, the statement is made: "There was an outflow from several of the borings which penetrated the gravelly material in the bottom of the deep gorge, although the tops of the casings were above the surface of the river."

I do not know exactly what that sentence means, but it seems to indicate that the water only flowed from the gravelly material in the bottom of the deep gorge. If that was the intention of the statement, it is without foundation, because, as you will see when you get this profile, the water flows through material practically anywhere from 32 feet nearly down to 258 feet, and doubtless if other borings were made in sufficient number water would be found at an elevation above 32 feet below the surface, as it has been at other places.

I think that is a very important point in discussing the safety of this proposed great dam—a very important point. The results of these borings show that that material is permeable, just as similar borings show that the material is also permeable at the Bohio site. There is this difference, however, that the permeable material at the Bohio site and above the Bohio site is coarser.

Senator MORGAN. Part of it is wood?

Mr. BURR. Part of it is wood, down at the Gatun site; yes.

Senator MORGAN. And at the Bohio site, too?

Mr. BURR. And at the Bohio site also; but it is coarser, as a whole, at Bohio and above Bohio than it is below. That is for the obvious reason that when material is brought down by the river current and settles upon this lower ground the coarser material will be dropped higher up the river, where the velocity begins to decrease, while the finer material will be carried farther down until the greater breadth of channel decreases the velocity, and causes the finer material to settle. But it is to be observed that at this dam site at Gatun there is a narrowing of the river valley, so that in geologic times past, when this deposition was taking place, the current in that contracted section was much higher than in the wider part of the lake shown upstream.

Senator MORGAN. You mean the speed of the current?

Mr. BURR. The speed of the current; so that there naturally would not be as much fine material deposited at the dam site as either above it, in the wider portions of the lake, or below it. But however that may be, it is absolutely certain that the results of these borings show the material, or a very large portion of the material, to be permeable.

Senator MORGAN. Let me ask you this question right there, if you

please: Is it your view of the geological gulch of which you have been speaking that it widens as it approaches the sea?

Mr. BURR. Not necessarily, but that is usually the case.

Senator MORGAN. But did the borings that you examined show that that gulch widens?

Mr. BURR. Yes; it is wider up in the wider parts of the lake than it is at Gatun, for instance, and it is wider in the wider part of the lake than it is at Bohio and above Bohio; but it is very irregular. The geologic valley, so to speak, was very wide through here. It narrowed down at Gatun. These high hills are points of rock sticking up, covered, of course, with clay and vegetation; and so it is with all this high ground. But the geologic valley, so to speak, was comparatively wide halfway between Gatun and Bohio, but narrow at both Gatun and Bohio.

Senator MORGAN. Is it your idea that that was originally an arm of the sea running up as high as Gamboa?

Mr. BURR. Probably, but we do not know. The elevation of the entire Isthmus, geologists think, has changed from one age to another, so that we do not know how far up the sea may have gone. But undoubtedly it had a very different delimitation inland from that which it now has.

Senator MORGAN. Have you ever seen any sharks' teeth that were found between, say, Gamboa and Miraflores?

Mr. BURR. I have not seen them; I have heard of them.

Senator MORGAN. You remember that Colonel Ernst saw them and found them?

Mr. BURR. Yes; I think he did. I had forgotten that for the moment.

Senator MORGAN. He found them 40 feet or 50 feet above sea level.

Mr. BURR. We have seen even more remarkable appearances in some parts of the Rocky Mountains, two or three thousand feet above sea level; we have there evidences of sea action and ancient sea life.

The very fact that this material filling the geologic valley is of an irregular character—some impervious clay, some mixture of sand and clay, and others of open sand, such as that penetrated by these borings—is, to my mind at least, demonstrative evidence that water may find its way through material under a dam of that character, with a head of 85 feet above it, which is equivalent to a pressure of not far from 40 pounds per square inch.

It is proposed to build this dam by simply cleaning off the surface material and then spreading the earth suitably selected from the canal excavation in layers, and so building it up to a height of 135 feet, making its base something like a half a mile wide. In my judgment that is a dangerous experiment upon a colossal scale which this Government is not justified in undertaking. I wish to say at this point that I have no objection to an earth dam anywhere under suitable conditions. In fact, I think it is a most valuable type of structure, and I do not see why an earth dam may not be built of any height if properly designed and founded. But in all cases it is my clear judgment—and that based upon years of experience in connection with the underground flow of water—that suitable means should be taken absolutely to prevent anything like flow through the permeable material under the dam; and no such means are provided in this design.

The means of accomplishing that end may take a variety of shapes. It may be a masonry core wall, if the bed rock is not too deep; and that is a common type of construction in this country. There are many such dams. Again, abroad, that core wall, instead of being of masonry, is sometimes of puddled clay; but that is equally effective to prevent any subsurface flow of water. In this country we have, within the past few years, constructed dams in some localities without either a masonry core wall or a clay core under conditions which justified that kind of construction; and those dams have stood satisfactorily. On the other hand, we have a record of numerous failures of earth dams from water getting through them and under them, sometimes through them along a pipe laid in the embankment, and sometimes by finding its way under the dams in precisely the manner that I should apprehend might take place in this case. There are numerous instances of that kind.

Senator KITTREDGE. Can you give us one or two?

Mr. BURR. I should have made a record of some of those dams, and I think I have a note of them.

A very complete account of some of those cases is found in a paper by Mr. William R. Hill, in the proceedings of the American Waterworks Association for 1902. One instance is that of the Mill River reservoir dam, at Williamsburg, Mass., which gave way on May 16, 1874. It was an earth dam, with a masonry core wall 43 feet high—about one-half the depth of water which would exist in this dam. Its area was 114 acres. One hundred and forty lives were lost, and about a million dollars' worth of property was destroyed.

That was, of course, a much lighter dam than this, and I would willingly accord all the additional presumption of safety to this dam which goes with its greater mass. But the failure of that dam shows what may take place in this dam or any other one of a similar character under similar conditions.

Then, again, there is a reservoir which has been completed for the Borough of Brooklyn, called the Milburn reservoir, which I have inspected in the course of my professional work for the city of New York, which was completed in 1893. That reservoir was completed under engineering specifications, with a puddled bottom, designed and put in place for the express purpose of preventing leakage. Yet when it was filled with 43,500,000 gallons of water it all leaked out in ten days, and that reservoir has never been in use since. That shows what water will do when it has a chance, even in so-called impermeable material.

As stated in the majority report, nothing is more common in the experience of waterworks engineers than to observe the underground flow of water through permeable or semipermeable material. In fact, many water supplies depend upon that flow, such as the Borough of Brooklyn and many other cities that take their water from the deep underground sands or mixtures of sand and earth. You will find frequently small passages of water, some of them threadlike in magnitude, almost capillary passages, and from that up to passages that flow many gallons a minute. There are wells fed by such water on Long Island; and in our recent examinations for a tunnel under the Hudson River near New Hamburg we found such a passage by diamond-drill borings, about 260 feet, if I recall the depth rightly, below the surface.

Senator KITTREDGE. When was that, Mr. Burr?

Mr. BURR. Perhaps two months and a half ago; and those are not uncommon experiences. They are within almost, you may say, the daily experience of hydraulic engineers or civil engineers engaged in that class of work.

You may make dams of sand, even, that will gradually silt up and be water-tight. There is no question about that. You may put a dam of this character at this place, and it might stand. I do not say that it possibly would not. But I do say that whether it will stand or not is mere conjecture. As an engineering guess, you might say that it probably would stand; but there is the imminent engineering possibility that the subsurface flow caused by this great head of water, 85 feet, would force a seepage—a mere seepage at first—which would gradually increase as it has elsewhere, coming up perhaps half a mile below the dam.

There is nothing uncommon about water flowing through a half mile of such material. If that dam were built and water were discovered coming up through the earth on the downstream toe and below it, it would be a source of continual apprehension as to what the result was going to be—whether the dam would not break out and discharge all its contents, as other dams have done, like the Mill River dam.

Senator MORGAN. Springs and rivers flow beneath mountains, do they not?

Mr. BURR. They do.

Senator MORGAN. And the mountains stand, as in the case of the Humboldt River?

Mr. BURR. They do; they stand. Sometimes, however, large banks of earth are carried away by precisely those springs. I have seen that a number of times.

In such cases the water comes from not great depths, but it has through long ages made a channel for itself, and it does not flow under any great head.

Senator MORGAN. The cores put into earth dams, I suppose, are intended to prevent this very underflow?

Mr. BURR. They are.

Senator MORGAN. Do they necessarily rest on the rock bottom?

Mr. BURR. Not necessarily. They may rest on a truly impervious bottom.

Senator MORGAN. A clay bottom, for instance?

Mr. BURR. Yes; or a hardpan bottom.

Senator MORGAN. Or hardpan?

Mr. BURR. Yes.

Senator MORGAN. It is not necessary to carry them down to the rock in order to make them useful?

Mr. BURR. Not necessarily; no.

Senator TALIAFERRO. Did not this Mill River dam have a masonry core?

Mr. BURR. That had a masonry core. Water found its way under that also, but it was not carried down to rock. It was constructed in an earth excavation.

Senator MORGAN. It was not carried down to rock?

Mr. BURR. It was not carried down to rock; no.

Senator KITTREDGE. What was the distance between the lower part of that foundation and the rock?

Mr. BURR. I can not give you the details, because I have not the data; but it was evidently pervious enough to let water through, because it led to the destruction of the embankment.

Senator MORGAN. Mr. Stevens seemed to lay great weight or stress upon the pressure of the superincumbent mass of earth of which the dam was to be composed, say, half a mile in cross section—that it would destroy the permeability of the material below if any serious difficulty of that sort existed. What do you think of that?

Mr. BURR. It would improve the condition, there is no doubt about that. Anything which adds weight to a permeable and compressive material will tend to make it more nearly impervious. But the question arises, Senator: Does the United States Government desire to construct this great waterway as a water connection between oceans, and practically for all time, and make its chief sustaining feature of such a character that its stability is not absolutely assured, so far as it can be by human means?

Senator MORGAN. I can only say in regard to that, that the United States Government did precisely that thing when they adopted your own recommendation for the dam at Bohio, and changed the whole canal system from Nicaragua to Panama. That was exactly what caused it.

Mr. BURR. I do not think, Senator, that the Bohio dam or even that plan was ever adopted by the United States Government.

Senator MORGAN. They did not adopt any other.

Mr. BURR. No; they did not adopt any; but they did adopt the recommendation of that Commission for the Panama route.

Senator MORGAN. And on that basis—that a dam could be successfully built at Bohio, and that that was the key of the canal.

Mr. BURR. It can be successfully built at Bohio.

Senator MORGAN. We will get to that later; but that was the basis on which we adopted it.

Mr. BURR. I think it is only fair and just to state, Senator, that if that were the basis (and it seems to me it is going a little too far to say that it was), that dam had a solid masonry curtain going down to what was supposed to be bed rock. We took no chances on seepage.

Senator MORGAN. You took no chances on seepage, except that you left 40 feet without being bored out at all between the 128 and the 168 feet depths, I will say—the difference between your borings and Wallace's borings. You left that without being bored out.

Mr. BURR. About 28 feet, I think—no; 40 feet; that is right.

Senator MORGAN. It is the difference between 126 and 168.

Mr. BURR. Well, those examinations were made as thoroughly as they could be with the time at the command of the Commission.

Senator MORGAN. Were they made with churn drills or diamond drills?

Mr. BURR. They were made with the jet boring process, but with appliances which permitted any boulder to be broken up by dynamite, so that there was not any essential doubt as to being on bed rock at the point where the borings were put down. But the deeper points which were subsequently found by our borings, made under the direc-

tion of Mr. Wallace and at the direction of the Commission, were not where the first borings were put down, but between them.

Senator MORGAN. On the same line, though?

Mr. BURR. On the same dam line, yes.

Senator MORGAN. The same dam line?

Mr. BURR. Yes.

Senator MORGAN. Now, your borings before that, that you had made in the Nicaragua examination, were made with diamond drills?

Mr. BURR. We used both at Nicaragua—both.

Senator MORGAN. But the borings at Conchuda were made with diamond drills?

Mr. BURR. Some of them were; not all.

Senator MORGAN. If there was any exception, it was not stated in the testimony that you gentlemen gave before that committee.

Mr. BURR. I think, Senator, that if you will look back at the report and at the evidence given, you will find that jet borings were first made, and then they were supplemented by the diamond-drill borings in the ordinary way.

Senator MORGAN. For greater certainty?

Mr. BURR. Yes.

Senator MORGAN. Now, why could you not have used those diamond drills at Bohio?

Mr. BURR. We could have used them at Bohio.

Senator MORGAN. Why did you not do it, then?

Mr. BURR. Simply because it was not considered necessary at that time, and both our time and our means were limited.

Senator MORGAN. You had a million of dollars.

Mr. BURR. We did, and we had to use even more than that.

Senator MORGAN. And two hundred and odd thousand dollars in addition was expended.

Mr. BURR. And still we did not use the diamond drills at Panama, even after exceeding our limit; but we made all that were considered necessary or advisable at that time. The French had made a number of borings there and all along the line. We supplemented those by all that was necessary, in our best judgment; but as engineers frequently fail to get all foundation information that may be necessary, we did not get all that was required to complete the information there.

Senator MORGAN. But at Bohio you were practically 50 or 60 feet deeper below sea-level than you were at Conchuda, on the Rio Grande?

Mr. BURR. I do not recall the figures at Conchuda; but it is about that, I think.

Senator MORGAN. Yes. So that greater care would have been necessary at Bohio for the reason that it was very much deeper below sea-level than Conchuda was? Greater care would have been required at Bohio?

Mr. BURR. Not necessarily, Senator; not necessarily.

Senator MORGAN. I do not see why.

Mr. BURR. The line through Nicaragua was actually, in its details, an unknown line. No work had been done on it. The exigencies of that route were far greater, from the conditions attending it, than they could possibly be at Panama, where an enormous amount of work had been done.

Senator MORGAN. Had any work been done at Bohio?

Mr. BURR. Yes.

Senator MORGAN. What had been done?

Mr. BURR. Not on the Bohio dam; but there was a great deal of work done in excavating lock sites there.

Senator MORGAN. At that location?

Mr. BURR. At that location; yes.

The CHAIRMAN. Senator Morgan, will you excuse me just a moment? Mr. Burr, do you think you could finish this afternoon?

Mr. BURR. I doubt it, Mr. Chairman.

The CHAIRMAN. The reason why I ask is that Mr. Bates, who was to appear here to-morrow morning at 10.30, is in New York, and would like very much to know whether we will be ready for him in the morning.

Senator MORGAN. You had better have him here at 2 o'clock, I think.

(A gentleman present in the room stated that Mr. Bates was in Washington at the present time.)

The CHAIRMAN. I thought he was in New York.

Senator KITTREDGE. Ought we to have a meeting to-morrow afternoon, inasmuch as there is going to be a vote on the statehood bill?

The CHAIRMAN. No; we can not have a meeting to-morrow afternoon. You think you will hardly finish to-day, Mr. Burr?

Mr. BURR. I think not. I think I can finish to-morrow morning.

The CHAIRMAN. I think, then, that we will have to ask Mr. Bates to come to us on Saturday morning at, say, 10.30 o'clock.

Senator TALIAFERRO. Mr. Burr, what is the essential difference between the earth dam, as recommended at Bohio, in the majority report, and this Mill River dam, which you say gave way?

Mr. BURR. The dam at Gamboa, did you ask?

Senator TALIAFERRO. No; I mean the majority report dam.

Mr. BURR. That is at Gamboa. Do you wish to know the difference between that and the Mill River dam?

Senator TALIAFERRO. Yes.

Mr. BURR. The difference is this, that if the Gamboa dam is built as a great earth dam with a masonry core that masonry core will be founded on bed rock, started from it. The masonry core of the Mill River dam was not founded on bed rock.

Senator TALIAFERRO. It did not go down to the bed rock?

Mr. BURR. It did not go down to the bed rock. I mention the Mill River dam only because I made a note of it; but there have been other failures where there was no masonry core. My only point is simply this, that in the construction of this dam, in my judgment—

Senator KITTREDGE. You now speak of the Gatun dam?

Mr. BURR. The Gatun dam. In my judgment very grave hazards as to the ultimate stability of the work are incurred, which it seems to me should not be incurred under such circumstances. If this were a power proposition, or a municipal waterworks proposition, even, where it was necessary for the party in interest to save every dollar that could be saved and he would be justified even in running some risks in order to be economical, that is one case. Such a hazard as that might be justifiable. But in this case, in my judgment, it is not justified. It is a piece of colossal experimentation, the failure of

which would involve altogether too great interest to be subjected to that risk.

Much has been said about the weight of water even on the bottom of the lake compressing it and making the material more impervious. I grant, as every engineer must (or any sensible man, it seems to me), that wherever weight is put upon a compressible material it will make it more dense. But there is one very pertinent observation to be made in connection with that pressure here—that in consequence of this irregular variation of material that settlement would not be uniform. It would be more at some places than at others, and that would cause a break in the bottom of the reservoir wherever that variation existed and form an opening for water to find its way into the deeper pervious materials.

The dams on the Pacific side are smaller and the risks, perhaps, may be of less magnitude; but they are of the same character and there is the same objection to them, in my opinion.

The dam between La Boca and the high ground opposite would be founded largely upon the most slippery kind of mud. Anyone who has been there and seen the bottom of the Rio Grande estuary exposed at low tide I think will agree with me that it is a very lubricating material; and if you were to put a bank of earth on it, even if it were half a mile thick, I think it would be in grave danger of being pushed out bodily. I have seen such banks on a smaller scale pushed out in precisely that way.

Senator MORGAN. Do you mean by the sea?

Mr. BURR. No; by the water of the lake, which would be some 55 feet above the sea, or even 65 at extreme low tide. It seems to me that in this great work the United States can afford to build structures of assured stability. Furthermore, it is my judgment that in any portion of its work that which is built or any procedure which is followed should be of such a character as to have the assurance of successful past experience to indicate that its use is justified. I would make no new experiments on the Isthmus of Panama in connection with this work.

Senator MORGAN. We have made one that has turned out to be very expensive by adopting a plan to build the canal with the key of the situation at Bohio. We have not commenced to build the canal yet, if I understand it.

Mr. BURR. I do not understand, Senator, to what you refer. The Bohio dam?

Senator MORGAN. Yes.

Mr. BURR. That was a perfectly safe type of dam, Senator. I should stand by that.

Senator MORGAN. If you had a safe place to put it.

Mr. BURR. That is precisely what I am advocating now. I am consistent with what I did then. Mr. Morison wanted to experiment in just the same way and I opposed him.

Senator MORGAN. The plan was good enough, but you did not have any place to put it.

Mr. BURR. Well, I would not hesitate, Senator, to make a perfectly safe dam at Bohio.

Senator MORGAN. Now?

Mr. BURR. Now; with the depth of 168 feet. I should not carry the masonry core all the way down, but I would make the dam safe.

Senator MORGAN. How much money would you spend on it?

Mr. BURR. Not such a great amount. I would make it within our estimate.

Senator MORGAN. Within your estimate?

Mr. BURR. Yes.

Senator MORGAN. And you recommend to-day the plan which your committee reported for a dam at Bohio for that canal?

Mr. BURR. If I were going to express my preference for a lock canal, Senator, I should say just what I said and argued for in the consulting board, that the canal should be made with the sea-level section on the Caribbean side carried to Obispo and on the Pacific side to Miraflores, and then lock up from those two points to perhaps a 60-foot summit level, possibly an 85-foot summit level, if you please; but if a lock canal were to be built, in my judgment that should be its plan.

Senator MORGAN. Where would you put your dam to make that 65-foot elevation?

Mr. BURR. I would put the controlling dam at Gamboa, just where the sea-level plan places it.

Senator MORGAN. Why would you not put it at Bohio?

Mr. BURR. With the subsequent investigations, made since, I should prefer to carry the sea-level section to Obispo, or nearly to Obispo.

Senator MORGAN. But Wallace's investigations have disproved the practicability of putting it at Bohio, have they not?

Mr. BURR. Oh, no; I should not be willing to admit that, Senator. His investigations have shown that it would be more difficult to build there than was supposed.

Senator MORGAN. They have shown 40 feet greater depth?

Mr. BURR. Yes.

Senator MORGAN. And that would be with caisson work?

Mr. BURR. Oh, I should not take caisson work down to that depth.

Senator MORGAN. What would you do, take ice down there and freeze it, on Hanna's plan? [Laughter.]

Mr. BURR. Well, the freezing process might be applicable, but I should not expect to use that. What I should expect to do would be to go down as far as it is feasible to go with the pneumatic process, perhaps to 140 feet, with the head of water above pumped down by making a great pit around the caisson; and then, from the lowest point reached by the pneumatic process, I would put one or preferably two lines of heavy sheet piling from that point down to bed rock, 30 or 40 or 50 feet, if you please, which would make a complete curtain and shut off all possible seepage.

Senator MORGAN. Then you would build your dam on the top of that sheet piling?

Mr. BURR. On the top of that I would place my dam.

Senator MORGAN. About how thick would you have that piling—I mean the cross section of it?

Mr. BURR. Perhaps 10 or 12 inches; perhaps not so thick. I should say from 9 to 12 inches.

Senator MORGAN. You would drive down piling?

Mr. BURR. It would not be driven down; it would be jetted down. You could use a hammer to a small extent, perhaps, in a caisson chamber properly designed for it; but I would expect to put that sheet

piling down by water jet, as is frequently done. There is nothing new about that.

Senator MORGAN. Would you make that piling of wood or metal?

Mr. BURR. That is an open question. I should prefer wood, because wood is indefinitely durable when it is saturated with water.

Senator MORGAN. But Wallace says that the timber that has floated in under the boulders that you struck there down next to the bottom of that gulch is rotten.

Mr. BURR. It decayed before it got there, then, if that is so, because we have excellent specimens of timber, you know, over two thousand years old, and I have myself seen oak branches in an excellent state of preservation taken from about 35 feet below the surface of the Harlem River in the northern end of New York. How long it has been there nobody knows, but for geologic ages, I suppose.

Senator MORGAN. Have you found any pine still existing in such places?

Mr. BURR. No; I have never seen pine.

Senator MORGAN. Would you make your sheet piling, then, of very hard wood?

Mr. BURR. Not necessarily. Any wood will endure if it is saturated.

Senator MORGAN. Then you would have a sheet piling down there which would prevent the permeation of water, and you would have your dam resting upon that?

Mr. BURR. No; the dam would not rest upon that sheet piling, Senator. It would rest upon the whole gravel base.

Senator MORGAN. Into which you had driven sheet piling?

Mr. BURR. Into which the sheet piling was driven. The function of the sheet piling would not be to support anything, but simply to make a cut-off for the water; and if it were found impracticable to run that sheet piling all the way across, you could inject cement in that gravelly material overlying the bedrock, and so close up any possibility of material seepage.

Senator MORGAN. And build a stone wall out of cement below there?

Mr. BURR. And force in the cement; yes.

Senator MORGAN. It is a stone wall after it is built, is it not?

Mr. BURR. Yes; that is it exactly; it is a stone wall.

Senator MORGAN. How would the structure thus formed compare, in respect of its security, with the proposed dam at Gatun that has been suggested by the minority of this committee? Which would you prefer?

Mr. BURR. I think it would be much superior to the proposed Gatun dam.

Senator MORGAN. It would?

Mr. BURR. In my judgment it would be far superior. In fact, it would be a structure beyond criticism—that is, it would be of assured stability.

Senator MORGAN. In constructing the Gatun dam, could they not use this sheet piling as well as you could at Bohio?

Mr. BURR. I think they could.

Senator MORGAN. Yes. Do you think they should?

Mr. BURR. And I think they should, or something equivalent to it.

Senator MORGAN. That can be done?

Mr. BURR. It can be done. Properly done, it would add largely to the cost; I do not know how much, but it could be done. I do not know whether you could carry the sheet piling down to 258 feet. I think that is a matter of grave doubt; but you might do something—

Senator MORGAN. You could do it with the assistance of the caisson process to get down to where you would start to drive your sheet piling, or to insert it through pumping out the material?

Mr. BURR. You could use sheet piling to a great extent, so far as it would go, and then resort to some such process as injecting cement—something of that sort.

Senator MORGAN. After all, that would be about the best plan, would it not?

Mr. BURR. It would if you could depend upon closing up everything; but when you inject cement in gravelly material you hope to close everything, but you can not always depend upon doing it.

Senator MORGAN. If you put pressure on it, you can do it.

Mr. BURR. You can get a large amount of cement into a very close material; but whether you could close up a geologic valley, so called, two or three hundred feet wide is another matter—you could doubtless close it up near enough for all practical purposes.

Senator MORGAN. Yes; that is what I am getting at. You could not make it water-tight, perhaps. That is all I have to ask about.

(The committee thereupon took a recess until 2 o'clock p. m.)

AFTER RECESS.

STATEMENT OF WILLIAM H. BURR, ESQ.—Continued.

The CHAIRMAN. Proceed, if you are ready, Mr. Burr.

Mr. BURR. The next feature of prominence in the plan of the minority is the group of locks—three in series at the Gatun dam, the single lock at Pedro Miguel, and the two at Sosa Hill. But I refer especially to the three in series at the Gatun dam. Unless the members of the committee desire to ask some questions regarding the safety of operation of the locks, I shall not add much to what is stated in the majority report on that point.

Senator TALIAFERRO. Is the question of the safety of operation of those locks fully set forth in the majority report?

Mr. BURR. Yes; it is fully set forth in the majority report.

There are only one or two matters which I wish to mention in addition to what is stated there. I wish to emphasize the fact that the experience in operating the St. Marys Falls lock is not a safe basis for forming a conclusion as to the safety of six such locks as those proposed in this plan, three of them being in series. In the first place, the lift of each of these locks is nearly 50 per cent greater than the lift at St. Marys Falls. Some of them have a lift fully 50 per cent greater. The dangers arising from a combination of machines or appliances are not simply in proportion to the number of parts or the number of machines. They increase at a more rapid rate simply because an accident to one may induce an accident to its neighbor.

An accident to one of the locks in series might easily extend to the lock below it, whereas if it were a lock standing by itself, as the lock

at the Soo is, the damage would cease with the one lock. So that the dangers arising from the operation of three locks in series are considerably more than three times the dangers that would arise from operating one of those locks by itself; and that is one of the reasons, though not all of the reasons, why a number of members of the board of consulting engineers recorded their objections against locks in series.

If a lock canal was to be built, they said—and I was one of the number—that it should be under such a plan that each lock would stand by itself, so that if any one lock should meet with an accident, the effects of the accident would stop there and not perhaps be communicated to others. In that way the damages resulting from serious accident would be limited. The minority propose to operate these locks in series in such a way as to make one ship follow another as closely as possible—that is, there would be two ships in the series of three locks at the same time, and their estimated capacity is obtained by assuming that there may be two ships; indeed, that there will be two ships at once going in the same direction in the series of three locks. I question very much whether it would be considered safe to operate that series of three locks in that manner.

The hazards would be doubled. That is, in the case of a ship running through the gates at the head of a lock, there would be almost certain destruction, not only of the locks, but of the ship below as well. It would be injudicious and unsafe to operate a lock canal in that manner, except possibly in some extreme emergency where it would be justifiable to incur that grave hazard in order to accomplish a very important end.

Senator KITTREDGE. Will a question interrupt you at that point?

Mr. BURR. No, sir.

Senator KITTREDGE. Suppose at some time it was desirable to have 25 ships of our Navy pass from the Atlantic to the Pacific, what would be the condition in reference to the operation of the locks and the time it would take for that fleet to pass through?

Mr. BURR. The effect would be a very slow passage of the fleet. The minority estimates, under ideal conditions that can never be attained, and which the members of that minority even do not claim will be maintained in the long run, that an interval of at least fifty minutes would have to elapse between two successive ships.

Senator KITTREDGE. Why is that?

Mr. BURR. Fifty minutes and thirty-nine seconds. It would require that length of time for one ship to get out of the way of another in this series of three locks—that is, it would not be possible to lock two ships through the canal any quicker, and through this triple lock, without that interval between them.

You would have to get one ship, you see, out of one lock and into the next before you could admit the second ship into the first lock, and that relative position between the two would have to be maintained through the lock. But, as a matter of fact, you could not put two ships through as quickly as that. There would be some little lost time. Instead of fifty minutes and forty seconds it would be at least an hour. Fifty minutes and forty seconds is but nine minutes and twenty seconds short of an hour. The interval, therefore, between two ships would be an hour. If all business of the canal were stopped in order to afford a clear passage for these naval ships, and if the

twin locks were used, it would take about thirteen hours, plus the sailing time between the locks, to get that fleet through.

That sailing time would not be less, probably, than eight hours—seven or eight hours—so that there would elapse twenty or twenty-one hours in which these vessels would be passing through the canal, one after the other, separated by intervals of one hour and incurring the hazard of two of these vessels at the same time being in this series of three locks.

We will assume that in the case of the sea-level canal all traffic would be suspended under precisely the same conditions. One vessel would then follow another immediately, and they would steam through uninterruptedly in seven to eight hours. It would take, therefore, very nearly three times as long to pass such a fleet through a lock canal as it would through the sea-level canal; and in the one case there would be comparative freedom from danger and in the other a grave hazard of crowding two ships at once into those locks and at the same time exposing them to the attack of some vicious enemy in that critical condition.

The question of the capacity of the lock canal follows, of course, immediately upon the consideration of this question of locks. It has been stated that the capacity of the lock canal, on the minority plan, is about 80,000,000 tons per year, with ample allowance of time for such repairs as might be required. A reference is made to experience with the St. Marys Falls lock to justify that high estimate of traffic capacity. It is worth while to consider in some detail the basis of that estimate. It is assumed for this purpose by the minority, and very properly, that in considering the maximum capacity of the canal it should be assumed that all vessels going one way should take one series of locks and all vessels going the other way the other series, the two series constituting the twin system of locks.

That is precisely what would be done and what should be done; but it is assumed that inasmuch as the three locks in the Gatun dam will consume the most time for passage of any single feature in the canal—greater, of course, than the two locks on the Pacific end—the period of time elapsing between consecutive ships in passing through those three locks will measure the capacity of the canal, because if the interval between two successive ships is small, you can keep ships going, provided they are there, in a regular procession; and the nearer any two adjacent ships are to each other intime the greater will be the number that enter the canal within twenty-four hours.

If two ships be supposed to pass through the Gatun locks as quickly as they can possibly be computed to move on purely theoretical grounds, with all conditions ideal, that period will be fifty minutes and thirty-nine seconds; that is to say, every fifty minutes and thirty-nine seconds a ship will enter the canal. So that, remembering that there may be this procession of ships passing in both directions the ideal capacity, the theoretical capacity of the canal will be determined by finding the number of minutes in a year and dividing that by 50.65 minutes, which is fifty minutes and thirty-nine seconds, and multiplying by 2, which gives 20,754 lockages, provided this whole procession is going day and night through the entire year.

It is impossible, of course, to have ships pass through the canal in any such ideal manner as that, and is so stated by the minority.

Judging from experience wholly with the St Marys Falls lock, they conclude that the number of practicable lockages will be two-thirds of that ideal, or, as they put it, "the coefficient of reduction is 68/100," which is practically two-thirds, and which would make 14,113 lockages.

Senator KITTREDGE. Do they make any allowance for the necessary time for repairs?

Mr. BURR. Not on that basis. I shall get to that, though, in a moment. There is no allowance made for anything on that basis except the incidental delays in getting to the lock and getting through it.

Assuming that each ship going through in this manner has a capacity of 5,000 tons net registry, the annual passage would be 70,560,000 tons.

Then, basing their argument upon further experience with the St. Marys Falls lock, which I will not read in detail, because it is not necessary to consume the time for that purpose, they assume that there will be fleets of ships passing through, so that each lockage will carry more than one, which is true, and that the aggregate of each lockage may be as much as 10,000 tons or more. So they conclude, on that basis, that the annual tonnage may reach 80,000,000 tons, with ample allowance of time for such repairs as might be required.

That is a very plausible statement, but I believe it is a very dangerous one to accept. I mean dangerous in that if the capacity of a lock canal is based upon such ideal conditions there will be serious disappointment in what it can do. In the first place, one-third of each year, approximately speaking, and very closely approximately speaking, the lock at the Soo is out of commission; that is, during four months of winter and the freezing weather at one end or the other of that period. That time is devoted to fundamental repairs and to putting the whole plant in order. These conclusions which I have just given you, and which can be verified by turning to pages 398 and 399 of the report, are based upon the eight months' working experience each year of the traffic at the Soo. There would be no such period on the Isthmus. The canal would always be in commission.

How much time should be taken out of the year to charge to necessary repairs of these great locks and their great machinery plants it is, of course, impossible to state definitely, but I should think that one-quarter of the whole time was not an excessive estimate. There must be some definite and material time given to that purpose.

Senator MORGAN. Is a quarter of the time requisite for repairing the locks at Sault Ste. Marie?

Mr. BURR. The locks there are out of commission, Senator, about four months in every year.

Senator MORGAN. I mean of the time they are in commission?

Mr. BURR. Oh, no, sir; when they are in commission the average may not be more than two or three days a month.

Senator MORGAN. Has it been that high even?

Mr. BURR. I think it has been higher, and it has been lower; but it is a small amount during the eight months. The repairs are all made during the winter—repairs to the locks and machinery. Three months may be too much or not enough; but there must be some time assigned to that. Suppose that instead of one-quarter it is one-sixth, if you please, to illustrate the point—and that is my only purpose. Sup-

pose we say that there would be five-sixths of the time in which the operation of these locks would correspond to the operating of the locks at the Soo during two-thirds of the time.

Senator MORGAN. But the twin locks, as proposed, would reduce that loss of time one-half.

Mr. BURR. No; I am speaking of each set of locks in itself. We are now considering, Senator, the maximum capacity of the canal when the traffic is very close to the limit.

Senator MORGAN. Very good.

Senator KITTREDGE. I understand you to say, Mr. Burr, that the capacity of the canal is limited, of course, by the capacity of the locks. Is that right?

Mr. BURR. It is limited by the capacity of the locks.

Senator KITTREDGE. That is the point you make?

Mr. BURR. Yes, sir; that is the point.

If, as I believe will be the case, it is first considered unsafe to rush ships through the locks in that way—two in a series at the same time—the interval, instead of being fifty minutes and thirty-nine seconds, will be eighty-four minutes and twelve seconds, or, say, an hour and a half. That alone would drop the traffic to about ten-seventenths. Both the Comité Technique and the former Isthmian Canal Commission of 1899–1901, who made a very careful study of this same problem, concluded from such experience as existed at those dates that instead of taking sixty-eight one-hundredths as the factor five-tenths only should be taken, and that, I believe, is as high as it is safe to take it. We shall have six locks on this canal instead of one, of approximately 50 per cent greater lift for each lock, and with all the contingent elements of delays, which increase, not pro rata, but in a higher ratio, where there are a number of locks in series and a number of locks to pass through.

Senator MORGAN. What plan do you refer to as containing six locks?

Mr. BURR. The minority plan.

Senator KITTREDGE. That has six locks, three on either side?

Mr. BURR. Yes, sir; three on either side, the total number being six. So that we should have to multiply $10/17$ by $25/34$, which is $43/100$, or, we will say, one-half. Those simple corrections, which are liable to be made and, in my judgment, will be made, would reduce the traffic from 70,560,000 to less than 35,000,000 tons.

Senator KITTREDGE. Do you know how that tonnage compares with that passing through the Suez Canal? Have you those figures in mind?

Mr. BURR. Yes, sir; I can turn to them right here. It is much greater. I think that the Suez traffic is about 19,000,000 tons, is it not, General?

General DAVIS. It has run nearly that in the last year; pretty close to that.

Senator MORGAN. Nineteen million?

Mr. BURR. Nineteen million tons.

General DAVIS. This last year.

Senator MORGAN. About one-half the capacity of the Soo?

General DAVIS. The Soo has run about 40,000,000 tons last year.

Mr. BURR. The minority, basing its conclusions upon the operations of the Soo lock, would make the time of passage through

this series of three locks eighty-four minutes and twelve seconds; that is, if I make no error; and if I do, I shall be very glad to be corrected by the minority. But, using their own figures, I get that result.

Senator MORGAN. May I ask right there whether any ships are excluded from the Soo now on account of their size?

Mr. BURR. I can not answer that question, Senator. There may be, on account of the draft, possibly. They are now enlarging it, deepening it. I am inclined to think that there have been a few such cases.

Senator MORGAN. Ships above that draft are excluded from the Soo—12 feet is it not?

Mr. BURR. I do not think there are any ships excluded from the Soo, because all the Lake ships, of course, would be built in view of the Soo locks.

Senator MORGAN. They would be excluded if they drew more than 12 feet, would they not?

Mr. BURR. Oh, no, sir; it is 20 or perhaps 21 feet over the sill—I have forgotten exactly what it is.

Senator MORGAN. It was formerly 12 feet?

Mr. BURR. Yes, sir; it has been increased a number of times. Of course, if there were any ships on the lake that required more water than would be afforded by the Soo lock on the sill they could not pass through it; but I do not think there is any such ship. In fact, there are not any such ships on the Lakes, because the Lake vessels are built for the purpose of meeting the provisions of the lake harbors and the Soo Canal. I will mention in passing—and I shall come back to that later—that a much larger and deeper lock is about to be built at the Soo.

Senator MORGAN. On the other side or on our side?

Mr. BURR. On our side.

On the basis, therefore, of the minority, the time of a ship passing the three locks in series would be eighty-four minutes and twelve seconds. Mr. J. W. Welcker, the Dutch member of the consulting board, who has had a most extended experience with large marine locks, makes a much more conservative estimate of the time required to pass this series of three locks. He would make the time, with a 1,000-foot lock (a little longer than if they were 900 feet) about one hundred and seventy-two minutes—nearly double. While it may be said that the minority estimate is based upon actual experience, it is equally true that Mr. Welcker's estimate is also based upon experience.

So you see that it is scarcely safe to take too sanguine a view of this quick passage of the Gatun locks. And even if we do accept the quick passage of the Gatun locks, the conditions of operation will, in all probability, be such as to cut its capacity from 70,000,000 down to less than half that, in order to avoid the unusual dangers which will accompany the operation of such a series of great locks. That estimate, even, is based upon conditions that can never exist. That is, it is based upon ships arriving at Colon or at Panama in series, on programme time, so that they can enter the lock immediately on their reaching the ends of the canal. Ships do not enter port in that way. They sometimes come at the right time to enter the lock immediately. They more frequently come in groups or fleets. Instead, therefore, of having this ideal adjustment of ships arriving

just at the time to go through, they will arrive in fleets or groups—remembering all the time that we are now considering the conditions of things which exist with the traffic capacity about at the limit of the provisions of the canal.

Suppose half a dozen ships—and under such conditions there might easily be more—should arrive at one end of the canal within a period of two or three hours. Only one at a time could enter the canal if the harbor were free on their arrival. The last of those ships would go through only after a delay of a considerable number of hours. And if other ships should arrive, as they probably would, while that group was waiting, those would be involved in a still greater delay, and so on. You would have a delay of hours upon hours, and it might be even days for some members of such an arriving fleet before they could get through the canal.

That is not an ideal or a theoretical condition. It is precisely the condition which the arrival of ships in ports ordinarily justifies. It is a condition which would inevitably exist if the number of vessels approaching this canal for accommodation anywhere near reached the limit of its capacity.

Senator MORGAN. Would not the same objection apply equally to a sea-level canal, where you had to pass a lock gate to get into it?

Mr. BURR. No; it would not, Senator. One-half of the time the tidal gates would be wide open, and the ships would simply pass in as fast as they arrived, one after the other, and during the extreme tides, when the lock would have to be used, it would be a single lock, like the St. Marys Falls, but with only half of the lift of that lock—that is, assuming that the tidal lock must necessarily be there, and that is what we do assume. So that there could be no such congestion with a sea-level canal, and that is, to my mind, one of the most important elements of the whole question.

It is impossible to avoid this congestion which I have just outlined when the traffic reaches any considerable magnitude. If there are only a few vessels coming now and then such conditions will be avoided. But it is simply impossible correctly to estimate a capacity for that lock canal which is even one-half of that assigned to it by the minority, taking into account the actual practical conditions which will inevitably exist when the traffic increases.

As a matter of fact, if you will imagine what will take place a little further you immediately reach a position where you find some ships that will never go through the canal but which will have to go around the lower end of South America to get to their destination, if they are passing from the Atlantic to the Pacific. Suppose you have a fleet of ships arriving within some one day, it being assumed that the ideal programme is that corresponding very nearly to the limit of the capacity of the canal, so that every eighty-four minutes, we will say, a ship goes into the lock.

The fleet of ships arrives, and it is followed by one or two at the ordinary intervals. Those ships pass in through the locks one after another, as soon as they can, and we will assume that, for the relief of the situation, there will be periods when no ships arrive, so that after a day or two or two or three days, if ships have been lying there that long, one of these void spaces occurs and they can all get through. That makes an equal balance. But suppose it does not occur that you have void spaces of considerable length, and then a

number of ships arriving are sufficient to more than make up for that vacant space, and suppose you have no void spaces after that time. You then get into such a confusion of congestion that some of those ships, theoretically—that is, figuring on the same basis which is used in the minority report—that some of those ships will never get through. That is, there must be a precise adjustment between the fleets and the subsequent void spaces in order to get them through the canal at all.

Of course there would be no such condition as a ship never getting through. The ship would get through, but others would have to wait in its place. There might be delays of a week or two, or two or three weeks, or even of a month, when the traffic reaches nearly the limit of capacity of the canal.

Senator MORGAN. But would not ships going, for instance, from Hongkong to Panama, as a matter of common practice, want rest and refreshment for their crews before passing through the canal and going on to Liverpool?

Mr. BURR. Many would. They would not stay there any longer than was necessary to accomplish their purpose; but they would want to stop for communication with the shore, to get their papers, to pay dues, and so on.

Senator MORGAN. To get fruits and market supplies, and so on?

Mr. BURR. Yes, sir.

Senator MORGAN. To get fresh food?

Mr. BURR. Yes; they would.

Senator MORGAN. That being the fact, that many would want to do that, would it not be desirable to have a lake inside the route in which they could make anchorage?

Mr. BURR. I should think it would be more desirable to have all that kind of business and those affairs attended to at the terminal ports rather than at any interior point, because, of course, the offices of the canal would be at one terminal or the other, and the markets for supplies would naturally grow up there.

Senator MORGAN. How about getting rid of barnacles, seaweed, etc., in fresh water?

Mr. BURR. I do not believe that any ship with a carload of freight would stop in any lake on the Isthmus to clean off its bottom.

Senator MORGAN. Even though it might increase its speed to the port of destination by two or three days?

Mr. BURR. There might be some extreme case of that kind, perhaps, but it would be phenomenal. I think that when a ship gets a cargo at one port and clears for another it is going to get to that other port and discharge its cargo and take on another one and earn its money just as rapidly as it can. Whenever its bottom becomes foul enough to require cleaning it will attend to that at some convenient port.

Senator MORGAN. How will it be with war ships that would have to go abroad to get into dry dock in order to be cleaned?

Mr. BURR. Well, of course a war ship is not subject to the same laws of business trips that merchant ships are. They might at times anchor in any convenient water, whether an interior lake or not.

Senator MORGAN. They would have to find the lake before they could anchor in it, would they not?

Mr. BURR. Yes; but they would anchor at the terminal ports.

Senator MORGAN. But that would be in salt water?

Mr. BURR. I did not understand your question. You mean for the purpose of cleaning their bottoms?

Senator MORGAN. That is exactly what I mean. I am speaking of vessels making trips from ocean to ocean.

Mr. BURR. I think they would go to a dock.

Senator MORGAN. How far do you think it would be preferable to go to a dock rather than to go into a lake of fresh water, that would clean them without any effort?

Mr. BURR. I am not a naval expert, but I know that the regular practice is not to go into fresh water, but to go into dock and clean up and make repairs.

Senator MORGAN. Is not the regular practice founded on the fact that the fresh water is not available, and they can not get into a lake?

Mr. BURR. But they can get into fresh water, Senator. There are many large rivers discharging into the sea that are perfectly accessible for ships of the greatest draft.

Senator MORGAN. But outside of the route of travel?

Mr. BURR. Some are and some are not. A war ship could go up the Hudson and get into fresh water very easily, but I have never heard of one resorting to that.

Senator MORGAN. Maybe the accommodations are not as good up the river as they are in New York for the naval officers. [Laughter.]

Mr. BURR. The attractions are greater at the city, I suppose. [Laughter.]

Senator MORGAN. But if they were compelled to take a route that had fresh water in it, they probably might loiter for a day or two or four or five days, or even a month, to clean themselves?

Mr. BURR. I think there would have to be some other reason than that before many of them would do it. I doubt very much whether that would be much of a consideration.

Senator MORGAN. We have had a good deal of testimony before this committee as to the great advantages of being able to clean a ship by putting it in a mass of fresh water. There has been a great deal of expert testimony on that point. I just wanted to ask you about it.

Senator TALIAFERRO. Do you suppose they would want to stop there in the Chagres country in the summer season and clean the ship's bottom?

Senator MORGAN. Well, I do not know about that. I suppose they could put mosquito bars all over the ship and keep the *Stegomyia* out. I suppose they could do that; yes. [Laughter.] It would be better, though, after all, to go through Lake Nicaragua, where there never was a case of yellow fever. [Laughter.]

Senator KITTREDGE. At some time before you leave this question of locks, Mr. Burr, I wish you would tell us about the decrease in size of the locks proposed by the minority over that as suggested by the full board. I do not know whether this is a convenient point or not.

Mr. BURR. Yes; that might just as well be taken up now as at any time. It is a short matter, only.

The law requires that this canal shall afford convenient accommodations for the largest ships afloat, or those which may be reasonably anticipated for the future. Of course it is a matter of judgment as to what that last provision may mean—what reasonable anticipation of the future is; but there are certain elements of the question which

are very plain. There are no ships afloat 800 feet long, but there are ships building 800 feet in length and 88-foot beam.

Senator MORGAN. Do you know where they are to run?

Mr. BURR. They are to run on the Cunard Line between New York and Liverpool. They are designed to run there. They are being built by the Cunard Line.

Senator MORGAN. Those big ships will be a mutual advantage to both countries?

Mr. BURR. I should say so.

Senator MORGAN. But if a big ship, 800 feet long, or one of the size of those Cunarders that are being projected, sails from Liverpool to Hongkong without breaking bulk, how would it be then?

Mr. BURR. I do not know that I understand your question.

Senator MORGAN. Well, suppose you load one of those Noah's arks at Liverpool with everything in the world that can be put into it—and 30 train loads can be loaded into one ship—and its destination is through this canal to Hongkong?

Mr. BURR. Yes.

Senator MORGAN. What advantage will the American people get out of that?

Mr. BURR. Well, if tolls are charged, they get the tolls, and if there is any collateral business done with the ship with American interests in the Zone, such as coaling, they will get the advantage of that. The indirect advantage of the stimulation of general commerce over the world is rather obscure and intangible, but still it is a real factor. Then, it is not unlikely, in fact, I should say that it would be practically certain, that if English interests should find it advisable to run great ships like that to oriental ports, American interests would not be far behind them.

Senator MORGAN. They would still be behind them, though, if not far behind, would they not?

Mr. BURR. I do not know whether they would or not. They might be ahead of them.

Senator MORGAN. They are behind them now in that, are they not?

Mr. BURR. They are now, but the present condition may not last.

Senator MORGAN. And they are very likely to stay behind. The small American ships would certainly be behind?

Mr. BURR. Yes.

Senator MORGAN. They would be very far behind?

Mr. BURR. There will always be a great deal of business for small ships. I think there is no doubt about that.

Senator MORGAN. In your investigations of this subject in regard to the size of locks, depth of canal, etc., have you ever taken into consideration the fact that Great Britain is not preparing the Suez Canal for the accommodation of these enormous ships?

Mr. BURR. Not yet; but I am impressed by the fact that ever since the Suez Canal was finished—and it was built as a private corporation—they have been doing nothing but enlarge it from that time to the present, and nobody knows when they will cease enlarging it. I think before they get through they will have accommodations for the 800-foot ships, or perhaps for larger vessels.

Senator MORGAN. I suppose that would depend upon whether we furnished a channel through which an 800-foot ship could go from Liverpool to Hongkong on a very much shorter line?

Mr. BURR. I do not know that it would, Senator. It might, but the dimensions of ships have been increasing steadily and rapidly for many years, and at the present time there is no evidence, so far as I know, to lead us to suppose that that increase is not to be maintained for some time in the future.

Senator MORGAN. That depends, does it not, upon the accumulation of capital in great navigation and ship-owning companies?

Mr. BURR. Doubtless.

Senator MORGAN. There is no doubt about that. Is there any necessity for providing accommodations for that class of people and cutting out the men or small companies that can not own those big ships?

Mr. BURR. I do not know, Senator, that that cuts out anybody. It is like all business. Those who are most favorably circumstanced to get the largest amount of business will get it, and others will get what they can.

Senator MORGAN. Is it necessary that we should provide ways and means by which the capitalists can combine in great companies for the purpose of killing off the smaller steamers?

Mr. BURR. Oh, no. I do not think that is the effect of such a waterway as this. In fact, it seems to me that a free and open waterway in any line of commerce, whether it is on this line or any other, will stimulate all lines of business, both those served by great appliances and those served by smaller ones.

Senator MORGAN. No sailing ship ever can pass through either a lock canal or a sea-level canal at Panama for the reason that it can not get away from there with its sails out through the doldrums. You admit that, do you not?

Mr. BURR. No, sir; I do not admit that it could not get away. There have been sailing vessels going in and out of the harbor of Panama for four hundred years.

Senator MORGAN. How many of them are going there now?

Mr. BURR. There are very few going anywhere now.

Senator MORGAN. There are plenty of them running up and down the coast and across the ocean in every direction.

Mr. BURR. Relatively a small number.

Senator MORGAN. Not relatively a small number. There is very close to a perfect equality in tonnage between sail and steam vessels to-day.

Mr. BURR. I know, in coastwise business.

Senator MORGAN. There are hydrographic surveys made by the Government covering a period of more than one hundred years that show that sailing ships can not afford to pass through the doldrums back and forth across the Pacific; that there is no wind. So that this Panama Canal will never carry a sailing ship through it that is destined, for instance, from Liverpool to Hongkong.

Mr. BURR. Well, I do not know about that, Senator. That may or may not be.

Senator MORGAN. Have you studied it?

Mr. BURR. Oh, yes; those questions have been before every commission that has considered this subject.

Senator MORGAN. Have they not deliberately resolved that it is better to sacrifice all the sailing ships and all their business than to miss having a canal through Panama?

Mr. BURR. I do not know of anyone that has done that.

Senator MORGAN. Have you not resolved that among the commissions that you have been on?

Mr. BURR. No, sir.

Senator MORGAN. Is not that the result of your action?

Mr. BURR. I do not believe that many sailing ships would ever use an isthmian canal wherever it might be placed. Although I think there would be one once in a while, it would have to be taken through with a tug, of course.

Senator MORGAN. Yes.

Mr. BURR. And it might have to be taken across the Bay of Panama by a tug, or it might not. It would depend upon circumstances. I have seen a great deal of wind about the city of Panama. I do not know how far down the bay it extends.

Senator MORGAN. Have you never investigated the proposition laid down in the hydrographic reports to the effect that a sailing ship can not pass through the doldrums with any possibility of a profitable voyage without being assisted from 200 to 600 miles into the ocean with a tug?

Mr. BURR. That may be.

Senator MORGAN. Is it not so?

Mr. BURR. Well, I do not know, Senator, as I should be willing to subscribe to so drastic an expression of it as that. The general features are in accordance with that statement.

Senator MORGAN. You are willing to go as far as the hydrographic surveys have proven the facts to exist, are you not?

Mr. BURR. Yes; certainly.

Senator MORGAN. Has your Commission or any commission that you have been on ever considered the question of cutting off the transportation power of the United States and excluding half of it or about half of it from the privileges of this canal that they are taxed to pay for?

Mr. BURR. That, Senator, is getting into a question that I should not hesitate to discuss if it were in line with these canal questions, but it does not seem to me to be so. There is no question about the fact that the vicinity of the Bay of Panama—in fact, the adjoining portions of the Pacific Ocean—are not attractive places for sailing ships, but I do not believe that the consideration of the disadvantages to sailing ships has ever had the slightest weight in deciding upon the Panama route. I believe that no sailing ships to speak of would ever use an isthmian canal, whether it was located at Nicaragua, Panama, or anywhere else.

Senator MORGAN. I would like you to state some reasons, if you have any, why no sailing ship would ever use the Nicaragua Canal.

Mr. BURR. Simply because it would be a very costly operation to take a ship through.

Senator MORGAN. For tugging?

Mr. BURR. Yes; and for tolls.

Senator MORGAN. From San Juan over to Brito?

Mr. BURR. It would.

Senator MORGAN. How much would it cost a ship?

Mr. BURR. I can not tell you exactly.

Senator MORGAN. Your reports show.

Mr. BURR. I am sorry, sir, that my memory has not sufficient capacity to enable me to remember the details of the figures.

Senator MORGAN. I will assume the responsibility of stating that it is very trifling, sir.

Going anywhere through there, direct across the ocean or up through that depression in the Cordilleras, across that lake, do not the trades blow perennially and powerfully as long as any trades blow?

Mr. BURR. There are strong winds blowing on the Lake of Nicaragua.

Senator MORGAN. And clear through as far as Hongkong—the trade winds?

Mr. BURR. You get fair winds in that part of the Pacific.

Senator MORGAN. Do you not get the whole force of the trade winds?

Mr. BURR. You get what winds there are.

Senator MORGAN. Well, they are the trade winds, are they not, just as certain as the tides?

Mr. BURR. The trade winds are not found off the coast of Nicaragua. The winds blow in the direction of the trades at times, but you lose the trades when you pass the Lake of Nicaragua, practically.

Senator MORGAN. Going which way?

Mr. BURR. Going from the Caribbean to the Pacific.

Senator MORGAN. To the Pacific?

Mr. BURR. Yes, sir.

Senator MORGAN. Well, I must leave you to the hydrographic surveys on that. I have no personal opinion about it, because I have never sailed through there.

Mr. BURR. I am speaking from my personal experience on the ground.

Senator MORGAN. I still have to confront you with the hydrographic surveys that show that the trades blow perennially through that funnel there, right out by Hawaii to the north end of the Philippines and to Hongkong.

Mr. BURR. Oh, yes, sir; there.

Senator MORGAN. Clear across the ocean. A man can set his sails there, put his helm in the right position, and never change his sails until he gets across, because he is carried over by the trades. Is not that a fact?

Mr. BURR. Well, when I was on the coast of Nicaragua, at Brito, there was a strong not quite southeast wind blowing, a strong wind up at Corinto, and, in fact, all down that coast on the Pacific side; but when we passed from Corinto to Panama there was practically no wind at all.

Senator MORGAN. From Corinto to Panama?

Mr. BURR. From Corinto to Panama.

Senator MORGAN. There was no wind blowing out from the coast?

Mr. BURR. No, sir. You practically lose the trades after you pass Lake Nicaragua in going from the Caribbean over to the Pacific.

Senator MORGAN. Where do they go? They blow perennially across the lake; then do they stop?

Mr. BURR. They do stop, as winds do here. We have a wind blowing in one part of the day and at night it ceases; and you have the same condition down there.

Senator MORGAN. If I am correct in my hypothesis—that the condition of the winds cuts off all the shipping through Lake Panama—would it not be a parallel case if these great steamers, 800 feet long or longer, should take the trade from the European coast to the Chinese coast in its effects upon the smaller classes of steamers?

Mr. BURR. I think that the effects upon the general prosperity of the country, Senator, should be considered, and not the effects upon some special portion. I do not believe, myself, that it would have that disadvantageous effect upon the smaller ships. I believe that there will always be a great trade and an increasing trade to be carried in the smaller vessels.

Senator MORGAN. You think that there will be a great and an increasing trade to be carried in the smaller vessels notwithstanding the competition of these immense vessels?

Mr. BURR. Notwithstanding the competition; yes.

Senator MORGAN. Notwithstanding the competition of these immense vessels that could carry as much as three or four of the smaller vessels?

Mr. BURR. I am aware of that, Senator, but their commercial field would be a different one from that of these great ships. We have large and small ships now, doing business in various directions, and I think we should always have them and always will have them.

Senator MORGAN. How about the coastwise trade of the United States that has to double the Horn now?

Mr. BURR. I think it would be very much benefited by this canal.

Senator MORGAN. Carrying it through by steamers?

Mr. BURR. Carrying it through by steamers.

Senator MORGAN. But a great deal of it is now conducted by sailing ships going around the Horn. Why not give them a chance?

Mr. BURR. They may have a chance. They may go through the canal if they wish to.

Senator MORGAN. But they can not get through.

Mr. BURR. They will have to be towed through by tugs, of course.

Senator MORGAN. And they will have to be towed out to sea from 200 to 600 miles, so that they can get a wind.

Mr. BURR. Very well.

Senator MORGAN. I was looking at the fairness of the treatment between two classes of people here that are supposed to have the same rights; but I suppose they have not got them.

Senator KITTREDGE. Mr. Burr, now tell us about the decreased size of the lock proposed by the minority.

Mr. BURR. The board decided unanimously, as I recall the vote—I think that was a unanimous vote, was it not, General?

General DAVIS. It was 2 to 11.

Mr. BURR (continuing). To adopt locks whose dimensions are 1,000 feet by 100 feet, usable length and width. While the vote was not unanimous, it was by a very large majority. The whole question of interests affected by the size of the locks was considered in connection with the past increase of ship dimensions, and it was felt that those dimensions were as small as should be adopted in view of the growth of ships during the past ten or fifteen years. It will be certainly from nine to ten years, and I believe it will be ten years from this time before the Panama Canal is opened to traffic.

Now, the increase in length of ships during the past ten years has been more than 200 feet. That, I believe, is a reasonable statement. It is not possible to state exactly how much the length of ships has increased year by year; but in looking back at the greatest ships afloat ten years ago and those which are now being built, the increase in length has been more than 200 feet. And, as I have already stated, there is no reason to believe that the rate of increase during the next ten years will be less than it has been during the past ten years.

Senator MORGAN. How long will the ships be then—a thousand feet long?

Mr. BURR. That would make ships approaching a thousand feet in length. It may be that that rate of increase will not be realized; but there is no reason whatever to suppose that it will not be very nearly realized. That being the case, a lock with a usable length of 900 feet will not be sufficient to accommodate the largest ships afloat at that time. The 1,000-foot length then will scarcely be sufficient.

Senator MORGAN. Let me ask you, right there, if a steamer a thousand feet in length would not find a great deal of trouble in getting around the curves in your Culebra cut?

Mr. BURR. I do not think so.

Senator MORGAN. You do not? Mr. Stevens seems to differ with you; but of course you have a right to your opinion.

Mr. BURR. I do not think that any ship even a thousand feet in length would have the slightest difficulty in getting around those curves. It would not go at the same rate of speed as a ship of half that length.

So that the size of lock which has been designed for this lock plan has a reasonable prospect before it of not being able to accommodate the ships afloat when it will be finished. I think, therefore, it is a lock of too small dimensions.

When we look back upon the history of canal building from the time of Telford and Brindley to the present day, one hundred and twenty-five years or more, we see one invariable procedure constantly repeated. That is the cutting down of summit levels, the increase in capacity of the canal prism, the increase in capacity of the locks. That has been the invariable history of every system of canal navigation in the world, I believe, practically, except some of those which were started in the early days of this country and went out of existence. But it has been so with all the European countries, from the small canals of England on to the present time. It has been so with the Suez Canal. It is so with the Manchester and the Kiel canals, and of course it has been markedly so with the Erie Canal. And now we see here proposed a feature of this great waterway so small that there is only one reasonable conclusion to be drawn from it—that it will be no sooner completed than that same process of reconstruction will immediately have to be begun.

That is not a strained view of the situation. It is in accordance with the strict facts of canal experience all over the world, and it has been so at the Soo. During the past forty years there has been nothing but a series of reconstruction of locks from the time the first lock was constructed there of any sensible dimensions; and with all the praise that has been given to the present Poe lock, for all its capacity, in all of which I join and accord fully, the United States

is to-day starting out to build a lock there with 75 per cent additional capacity to the Poe lock at the present time.

That is the history of the continuous reconstruction and reconstruction and reconstruction of the locks of the Soo; and that is not an exception.

Senator MORGAN. Is that increase in the size of the ships and the depth under water on the sills of the locks due to the increase of commerce?

Mr. BURR. It is due to the increase in demands for accommodation—yes; the increase of commerce.

Senator MORGAN. Have we not had full capacity in that canal to accommodate all the commerce that has passed through it for the last thirty-six or forty years?

Mr. BURR. We have certainly passed all the commerce that has sought it; but we would spend three times—yes, perhaps ten times—as much as has been spent to dig away that lock and have a free and open entrance into Lake Superior if it could possibly have been done. I do not suppose that the most ardent advocate of the Poe lock at the present time could deny that were it physically possible to take away every obstruction to and constriction of the lake commerce at the Soo, it would be taken away, leaving a free and open passage into Lake Superior; and in that case there would be more ships and more commerce than there is to-day passing that place.

Senator MORGAN. Are not the real facts at the Soo these—that the necessity for a greater lock is not so much to accommodate commerce that has not hitherto been accommodated as it is to enable the great capitalists to concentrate their money in building larger ships and cutting the smaller ones out of the Lakes?

Mr. BURR. Well, Senator, I do not take such a sinister view of the intentions of the business men of the Northwest. I do not believe that they desire to annihilate all business except their own. They are like all business men, I suppose; they desire to extend their business and make it as prosperous as possible.

Senator MORGAN. Have you known of any instance where combinations of capital are possible that they did not go into them for that very purpose?

Mr. BURR. Well, that is true.

Senator MORGAN. Yes; that is true.

Mr. BURR. Those are great questions which—

Senator MORGAN. If it is true in other businesses, it is equally true in controlling the commerce or navigation on the Lakes.

Mr. BURR. But whatever may be the details of the situation, the actual facts stand—that in all canal enterprises up to the present time the end, aim, and motive of the management has been to reduce obstructions to navigation and increase the capacities of the canals by eliminating locks wherever it is possible, and where it is not possible by increasing their size, and there has been a constant system of reconstruction going on at the Soo in accordance with that general result.

Senator MORGAN. Has not that been under the pressure of capital that demanded larger opportunities for monopolizing the trade?

Mr. BURR. Well, is not that simply saying, Senator, that business has increased and will increase, and that provision must be made for it? It may be that some features of business development are not

conducted in the most commendable way. That is undoubtedly so. Few things human are perfect. But it strikes me that what we have to consider in this view is, what has been the experience with canal constructions and canal enterprises heretofore as to capacities of the canals and the means of giving them additional freedom and greater accommodations for the traffic seeking them? And, to my mind, to constrict the capacity of this great canal by a small lock for the apparent purpose of paring down the cost of construction to a relatively small amount, is contrary to good public policy or good business judgment.

Senator MORGAN. That seems to be the prevailing opinion amongst all large money holders.

Mr. BURR. Well, I am not one of them, Senator. Civil engineers are not found in that company.

Senator MORGAN. With their present salaries, I do not see why they might not soon get into it. [Laughter.]

Senator KITTREDGE. You have not touched the question of the cost of these locks, as I recollect, Mr. Burr.

Mr. BURR. I can give you those figures.

The item of the Gatun locks, including excavation and back filling, is \$15,691,000.

The Pedro Miguel locks, including excavation and back filling, \$6,988,000.

The Sosa locks, including excavation and back filling, \$13,092,000.

Senator KITTREDGE. By "back filling" at Gatun do you mean the Gatun dam proper?

Mr. BURR. No.

Senator KITTREDGE. Is that amount included?

Mr. BURR. The Gatun locks are located in a hill, a natural hill. It would involve excavation into the hill and the rock which composes the subsurface material of the hill, and there would be some back filling—large quantities of back filling.

Senator KITTREDGE. As I recollect the figures you gave yesterday, the cost of the Gatun dam was, in round numbers, \$7,800,000. Is that right?

Mr. BURR. That is right. That is a separate item, in addition to the cost of the locks.

Senator KITTREDGE. And do the figures that you have given of the cost of the locks at Sosa Hill include the cost of the dams there?

Mr. BURR. No; the cost of the dams is a separate item, as I have already given it. These costs of the locks are separate from and in addition to the sums which I have named for the cost of the dams.

Senator KITTREDGE. Can you readily give the total estimated cost of the dam at Gatun, the Gatun locks, the locks at Pedro Miguel, the locks at Sosa Hill, and the three dams at La Boca, Sosa Hill, and from Ancon over by the railway? I have forgotten the name of that hill.

Mr. BURR. Yes. The Gatun dam and spillway is \$7,788,000. The three dams (that is, the La Boca, the Ancon-Sosa, and the Ancon-Corozal dams) amount to \$3,320,000. The Gatun locks amount to \$15,691,000. The Pedro Miguel locks amount to \$6,988,000; the Sosa locks, \$13,092,000. The total cost of those features is \$46,879,000.

Senator MORGAN. Dams and locks?

Mr. BURR. Dams and locks.

The CHAIRMAN. Mr. Burr, how large a ship can go through those locks?

Mr. BURR. A ship 900 feet long and with beam less than 95 feet. Those are the usable dimensions. Of course the total length of lock is much more, but the usable dimensions are 900 feet by 95 feet.

Have you any more questions on that point?

Senator KITTREDGE. None. At some convenient time I would like again to call your attention to this blueprint that has reached us during the recess, if you have finished with the locks. Have you?

Mr. BURR. Yes.

Senator KITTREDGE. I call your attention to this blueprint, and ask you whether this map was the original from which plate 12 was supposed to be taken?

Mr. BURR. That is my understanding—General Davis can tell you—that that is the original from which this plate is made. This, as I understand the situation, is the only map in Washington giving that information.

General DAVIS. Yes.

Senator KITTREDGE. In what respect do they differ?

Mr. BURR. I have not examined every item of information on it, but so far as I have examined this profile on line G H (and I have given it pretty careful examination) it shows practically everything except these items relating to the flow of water through the boring pipes from the various strata indicated.

Senator KITTREDGE. Then, from the blueprint, call to the attention of the committee and put in the record what developed from the borings in regard to water coming to the surface through these borings—at what depths, how close to the surface.

Mr. BURR. The material in a number of the borings was found to be sufficiently permeable to permit water to flow through it into and up the boring pipes from various depths, commencing about 32 feet below sea level and running down nearly to the greatest depth of 258 feet below mean tide—that is, water flowed from this material at various points in these various borings between those elevations.

Senator MORGAN. You mean that as the pipe was driven down the water would rise in it and pour over the top?

Mr. BURR. When it penetrated these various strata.

Senator MORGAN. Yes.

Senator KITTREDGE. Now tell us about the strata to which you have referred. What is the character of it?

Mr. BURR. It is a sandy or gravelly porous strata.

Senator KITTREDGE. And that is indicated upon the blueprint?

Mr. BURR. The character of material is indicated upon the blueprint.

Senator KITTREDGE. State from the blueprint what it is.

Mr. BURR. It is sand, gravel, and sometimes a mixture of sand and clay. That is the character.

Senator MORGAN. I suppose that the process of getting these borings is that they drive the pipe down until it strikes the rock and then insert their augers, their drills, and bore?

Mr. BURR. Yes; for the diamond drills, but for the jet borings they put down what we call a casing pipe, and then wash the material out with a smaller one.

Senator MORGAN. I understand the difference; but for the diamond

drills you drive your pipe until it strikes the rock, or until you strike material you suppose to be rock, and then you introduce the drill and bore?

Mr. BURR. And bore; yes.

Senator KITTREDGE. The statement was made by Mr. Stevens, and I think it is stated in the minority report, that one great advantage of the lock system is that ships can sail over a wide surface of water until they approach the Culebra cut. Am I correct in my statement?

Mr. BURR. It is the intention of the plan that in all except the deepest parts of the lakes ships should pursue perfectly definite courses, as shown on the maps, and through submerged channels. A ship can not sail at random anywhere in those lakes, except over comparatively small portions of them, where the water is very deep.

Senator KITTREDGE. In what manner was it expected that these channels would be marked out?

Mr. BURR. They would have to be buoyed, as submerged channels always are; and that is one feature I had intended to speak about. Perhaps I might as well make my statement now.

Senator KITTREDGE. Certainly.

Mr. BURR. Much has been made of the fact that these lake channels are wide—500 feet or 300 feet—and that consequently a vessel has much more freedom in them.

Senator MORGAN. Let me ask you there, are those wide channels that you speak of represented by the white area or by this shading of blue on that map?

Mr. BURR. They are represented by the limits of this portion of the white area.

Senator MORGAN. Yes.

Mr. BURR. But it is not in here [indicating]. In here we have very deep water.

Senator MORGAN. The shading of blue comes in to show that it is not navigable water, I suppose?

Mr. BURR. Well, no; I think not. I think that simply indicates the margin of the lake; that is all. I do not think the blue has any particular significance as to navigation.

Senator MORGAN. I notice there above Alhajuela that it is cut off entirely.

Mr. BURR. Well, it does cover shallow water—the margins are shallow. I do not know that the limit of the blue has any special significance, although it may have.

Senator MORGAN. I had supposed that the white area on that map was the area of water that was navigable for vessels with freedom, and that the blue area was an indication that the water would not be deep enough for that purpose.

Mr. BURR. It may be. Just let me read the legend. [After examining map.] It is stated here that the blue indicates "shallow water, with less depth than in adjacent canal." Well, that is about what it would be.

Senator MORGAN. Yes. That describes, then, the channel depth of the canal on those wide areas?

Mr. BURR. Yes. The white portion, it is stated here, indicates navigable water more than 41 feet deep for the Atlantic entrance and more than 45 feet deep from Gatun to the Pacific terminal, referred to mean tide and to mean lake levels.

A channel with submerged banks not rising to the surface of the water, so that they are invisible, is obviously in itself a very dangerous channel for navigation. Consequently its under-water limits must be buoyed. Even in that case the difficulties or dangers peculiar to such a channel are not altogether avoided unless the channel is very wide. It was necessary, therefore, in this plan, to make the submerged channels wide enough to lessen those dangers to navigation.

A much narrower channel would have equal safety to navigation, and perhaps greater safety, with its banks above the water so as to be visible to ships' pilots. Just what increased width for the submerged channels would be necessary to secure equal safety and freedom with the channel with banks visible I do not know that anyone can estimate; but I think that the least width that could be assigned to a submerged channel for that purpose would be double the width of a channel with visible banks. That accounts for the wide submerged channels in this plan. It is a wise provision; in fact, it would scarcely be a workable plan without these increased widths.

Those difficulties and dangers have been frequently encountered in the interlake navigation, in St. Marys River, Lake St. Clair, and Lake Huron. They have been frequently remarked upon, and while it is not definitely stated, in Appendix S, by Mr. Ripley, of the minority, as to the details of his reasons, there are one or two very significant passages. [Reading:]

For widths less than 300 feet smooth vertical sides should be provided—

He is speaking of channels in connection with that navigation, although making a general application of the experience there. He says:

For widths less than 300 feet, smooth vertical sides should be provided for the greater safety of ships; while for widths of 500 feet or more, submerged channels can have side slopes such as the material will naturally assume, or as will be left by the excavating machines.

The implication is that a channel with submerged banks ought to be about 500 feet wide, or more; and I think that it is a very judicious observation. That observation carries with it the significance which attaches to the danger of submerged banks.

Senator KITTREDGE. What about the relative curvature of the canal as proposed by each?

Mr. BURR. I will answer that, Senator, in just a minute, if you will excuse me.

Senator KITTREDGE. Certainly; I thought you had finished.

Mr. BURR. I was looking for some information.

In speaking of the navigation between the Lakes in channels large portions of which have submerged banks, though by no means all—perhaps not the majority of them, but still considerable portions have—he says:

In 1904 there were 34 groundings, principally during foggy weather.

The groundings would naturally be on the banks of the channel, and not in the center. [Reading:]

In 1905 the number of accidents was about one-third less. Each year the grounding of ships on the channel banks, or sinking in the channel on account of collisions, has temporarily interfered with navigation.

And so on. That is, the feature of submerged banks is a feature of difficulty and danger to navigation, and requires the most thorough buoying of the submerged banks, and any other provisions that may be necessary to secure immunity from the resulting damages.

You spoke, Senator, of the curvature.

Senator KITTREDGE. Yes. The relative curvature of the two plans, sea-level and lock.

Mr. BURR. I would like to say, in this connection, that in my judgment the curvature of either line is not a matter of any very great consequence; the amount of it is not sufficient to be serious. But inasmuch as the channel of the sea-level canal has been criticised as narrow—although it is the widest canal prism that has ever yet been proposed for similar navigation—as wide as the turning-out places of the Suez Canal—and crooked, I will refer briefly to the matter.

As a matter of fact the total curvature of the lock plan, as laid down on page 12 of the minority report, is 637° and $30'$.

Senator MORGAN. That is the total?

Mr. BURR. That is the total. The total curvature of the sea-level canal is 597° and $6'$. The difference is not great, but it is several per cent in favor of the sea-level canal.

Senator KITTREDGE. Do you know the curvature of the Suez Canal?

Mr. BURR. I do not. I can very easily get it.

Senator MORGAN. I wish you would state the smallest curvatures, the shortest radius in both canals.

Mr. BURR. The shortest radius in connection with the minority plan is a little difficult to determine, because it is a matter of computation, and is not shown. But taking the curves as they actually exist, the shortest radius of curvature is 1,700 feet. The shortest radius of curvature on the sea-level canal is 8,200 feet.

Senator MORGAN. Where is that 1,700 feet in the lock canal?

Mr. BURR. I do not recall, Senator, just where it was. I can very readily ascertain.

General DAVIS. Very near Bohio.

Mr. BURR. Very near Bohio. I presume it is right there [indicating].

Senator MORGAN. Where is that? Is that Bohio?

Mr. BURR. Near Bohio.

The total length of curve of the canal is much less in a lock canal than in a sea-level canal. It is 7.3 miles in the lock canal and 19.2 miles in the sea-level canal; but with the great radius of curvature of the sharpest curves in the sea-level canal that curvature is not a matter of great importance.

Much has also been said in connection with this matter of curvature to the effect that ships' pilots never like to sail their ships on curves, and in fact do not do it, but simply change their courses by ranges in such limited navigation as this.

The many years of experience on the Suez Canal, I think, may safely be referred to as settling that point. Ships are constantly sailed on curves in the Suez Canal. It is built for that purpose. They could not well sail in any other way; and even in the lock plan of the minority, the course is laid out on curves. It is laid out on curves simply because the pilot of a ship can not sail his ship in any other way. He has to change his course, and he can not change it

by rotation about a point. He has to sail his ship on a curve until his course is sufficiently changed to give him the next tangent. So that that criticism of sailing on curves being impracticable on a sea-level plan and avoided on the lock plan, is without any foundation whatever. Curves are contemplated on the lock plan, as shown by the minority's own plan.

Senator MORGAN. I do not understand that the minority says that it is impracticable, but that it is dangerous in the places where the walls are rock on either side.

Mr. BURR. I am not referring to the minority alone. Other parties have made observations of that character, but the minority have also done so. But, as a matter of fact, that feature is common to both plans; and I do not see how a pilot can sail a ship in any other way. He can not, as I said a moment ago, rotate his ship about a vertical axis in order to change his course. He keeps going, and that naturally brings him on a curve, and experience in the Suez Canal shows that that is not a matter of any inconvenience whatever to ships. They do it there constantly.

Mr. Quellenec, the French member of the board, who is the consulting engineer for the Suez Canal and has been for many years, made that explicit statement himself.

There is one other feature in connection with the Gatun Lake which bears upon the cost of maintenance of both plans, which, it seems to me, has not yet received the attention which it deserves, and that is the fact that all the sediment of every stream whatever found in this saddle of the Isthmus, through which the canal passes, is discharged into Gatun Lake, and the largest part of it so discharged as necessarily to silt up the channel to a large extent. I am aware that computations may be made which show that the total sediment brought down by the Chagres River, and possibly other streams, so far as that is known—and it is not very well known—will fill up Gatun Lake only after a long period of years. But that calculation is like a good many other plausible calculations on which conclusions are too abruptly based.

If the sediment were brought down and distributed uniformly over the entire lake, that would be true. But rivers do not bring down sediment in that way. Nothing is a matter of more common observation—in fact, it was stated by General Abbott himself during the sessions of the board—than that where a river comes down through a wide channel or a wide passage, many times in width the channel proper, the current will be concentrated along that channel—that is, along the deepest part of the moving water. That is constantly observed in the Mississippi River in times of flood, when miles of width of the valley are inundated. The main current, which is a rapid one, will be found over the channel of the river proper, and that is precisely what would be found here when the Chagres River is in flood. The rapid current, by far more rapid than at any other part of this lake, will be over the original channel of the Chagres River, because it is there deepest and the flow easiest—that is, the movement of the water meets with less resistance there—and consequently there the highest current is found.

The result will be that the greater part—not all, but the greater part—of the silt, the sediment which is brought down from the Upper Chagres in flood, will be carried down through this narrow

portion and dropped in the channel of the canal at least all the way to Tavernilla. In other words, instead of providing a great lake into which the silt can be brought and where it will be deposited without danger to the channel, it must be transported right along the canal line as it emerges into the wider portion of the lake, and will necessarily be deposited there, necessitating annual dredging to keep the channel clear. And I want you to observe particularly the narrow portion of this lake between Gamboa and Tavernilla. It is narrower there even than it is above Gamboa. There is a strip of canal prism which will be just as surely subject to deposition of large quantities of silt as this canal is excavated. It will be not a prohibitory expense at all, but it will be a large constant annual expense and trouble to get it out.

Senator MORGAN. You mean the current will pass on and the silt will flow off to the right and left of it?

Mr. BURR. That will be the result. It will take place to some extent right here, but it will also take place all the way down [indicating on map]. It does that in other places, and it will do it there.

Senator MORGAN. Well, that would have the same effect as the water passing down from the upper sources of supply through the sea-level canal; it would create currents, particularly in the part that is dredged out from the Bay of Limon up to, we will say, Obispo, or in that vicinity? That same disposition of water to pass in the channels where there is the least resistance would naturally create currents in the canal?

Mr. BURR. Yes.

Senator MORGAN. What would there be to resist that in a sea-level canal—the Chagres pouring in?

Mr. BURR. The same results will not take place with the sea-level plan, because, as I explained yesterday, no sediment is permitted to flow directly into the canal.

Senator MORGAN. I am not speaking of the sediment; I am talking about the currents that would interrupt navigation.

Mr. BURR. There are none in the sea-level plan.

Senator MORGAN. Would they not necessarily be there if you permit the Chagres River at its extreme high flood (as you would be obliged to do) to pass into the canal prism?

Mr. BURR. But, Senator, it does not pass into the canal prism at high floods. A limited quantity only is allowed to flow into the canal prism, which will never produce from the Chagres a greater current than about a mile and a quarter an hour, having no sensible effect upon navigation, and even that is not necessary. It be smaller still.

Senator KITTREDGE. As I recollect, you stated yesterday afternoon may be smaller still.

Mr. BURR. Into basins.

Senator KITTREDGE. And from those basins it flows over a weir into the canal?

Mr. BURR. Into the canal. It flows over in a quiet sheet. The sediment is all deposited, except an insensibly small amount, which may discolor the water, but all the great body of sediment, the great volume of sediment, is left in the sedimentation basins, the Gamboa Lake itself, of course, being the greatest sedimentation basin.

The same result, obviously, is likely to take place where any stream inflood flows down into these lakes. In other words, in the lock plan there is no provision whatever for preventing silt and sediment getting into the canal basin, and it will entail an item of cost for maintenance of a very considerable amount but which the sea-level plan is free from.

Senator KITTREDGE. You spoke yesterday of the banks in the Culbra cut slipping. To what extent is that true of the lock type?

Mr. BURR. What I think you refer to is the slipping clay—

Senator KITTREDGE. Yes.

Mr. BURR (continuing). At the top of the cut, and which can be readily controlled by either draining it or removing it. That feature is common to both plans. Perhaps a little less of it will have to be removed for the lock plan, and yet not much less, either. It is practically the same item for each plan. I do not think it is a serious matter, however; but what there is of it must be encountered in construction, whatever the type may be.

Senator MORGAN. As to the seriousness of that avalanche of slipping clay, there is a good deal of testimony in the record of this committee on former examinations to the effect that railroad tracks and railroad trains of cars, while the French were working it, were covered up and remain covered yet.

Mr. BURR. I have heard those same stories, Senator, but as much as I have been on the Isthmus—and, as I said yesterday, I have walked backward and forward, I believe, over that whole line I do not know how many times; perhaps a dozen times, eight or ten times anyhow, and talked with many who ought to know about that sort of thing—I have never yet been able to place that engulfed train of cars.

You will find plenty of them on tracks in the jungle, standing there now, which have never been washed away; but I do not believe that any such occurrence as that mentioned ever took place. It is quite possible—in fact, it is altogether probable—that in some places, more than one, perhaps a number of places, tracks have slipped down the side of a hill and thrown the train over, and it is altogether probable that a good many of those cars, or a number of those cars, were never taken up, so that they have been covered up in the dump. I myself have seen such a thing as that taking place—I did only last October—where some cars have gone off the dump. They were old French cars, not worth the trouble of picking them up, and they were allowed to lie there and be covered with mud; and I imagine that that has been the source of these statements.

Senator MORGAN. I suppose it must have been. Your description of it is bad enough, but they made it a little worse.

The CHAIRMAN. Mr. Burr, would you be able to finish to-morrow, say, from half past 10 to half past 12?

Mr. BURR. Oh, I think without doubt, Senator.

The CHAIRMAN. I thought you were tired, and perhaps you would rather that we adjourn now.

Mr. BURR. I am willing to go on longer.

Senator KITTREDGE. Before you leave us, Mr. Burr, I would like to have you tell us about the comparative time of the construction of the canal on each type, and also the question of comparative cost, and the question of maintenance and operation of each type.

Mr. BURR. That is, to-morrow morning?

Senator KITTREDGE. This afternoon or to-morrow morning.

Mr. BURR. I am perfectly willing to go on to any extent this afternoon.

Senator MORGAN. Let us go on and get as far as we can.

The CHAIRMAN. Let us go on a little while, then.

Senator KITTREDGE. We will be away to-morrow afternoon.

Mr. BURR. What item will you have taken up first, Senator?

Senator KITTREDGE. It does not matter to me. Suppose you take up the time of construction under each type.

Mr. BURR. The time of construction for the sea-level plan was discussed yesterday. I stated then that, in my judgment, the sea-level plan could be completed in ten years, and that if we add 25 per cent to that, as the majority has done, we certainly have a most abundant allowance of time.

There was one thing which I should have stated in this connection yesterday, which I did not. That estimate of time has been based upon an eight-hour day of labor, and with one shift per day only. I believe that when the time comes for the construction of this canal, over a considerable portion of the time required for its completion two shifts of men per day can be worked to great advantage; and I am not alone in that judgment. It is perfectly feasible, and in some respects it is a very advantageous arrangement. It gives the cool of the day for the greater part of the work, and it would double the daily product of operations and, obviously, shorten the time correspondingly. So that when I say that the sea-level plan can be completed, in my judgment, even within ten years, it is not an extravagant assertion; it is a well-founded one.

Senator KITTREDGE. In your estimate of ten years, do you estimate the feature you have just mentioned—double shifts?

Mr. BURR. No; that is based upon single shifts. But, I say, that if you add, as the majority has added, 25 per cent of ten years to itself, making twelve and one-half years, or from twelve to thirteen years, as the period (which is certainly a very generous allowance of time, one which, I think, is even too great), and if in addition to all that you work two shifts of laborers a large portion of the time, as it is perfectly feasible to do, the time will certainly be much decreased.

The same general observation applies to the construction of the lock plan; but there are some other elements in the estimate of time for the lock plan which do not make toward a shortening of the period of construction, but which make for its lengthening.

The work of digging in the great Culebra cut, which is the controlling feature of the sea-level plan, is the simplest kind of labor, the simplest labor operation that is ever done. It is the simplest that can be done—the simple digging and carrying away of the material.

The construction of the locks required in the lock plan, the building, transporting, and putting together of the machinery and locks, requires about the highest grade of skilled labor, on the contrary, which is ever employed in engineering construction. The employment of such skilled labor and such a skilled force is accompanied by many difficulties and great delays. All that machinery must, of course, be constructed here, just as locomotives are, sent down there in piecemeal, and put together under circumstances that are not by any means encouraging or calculated to expedite results.

That experience has already been found in connection with the loco-

motives and the steam shovels and other machinery which has been sent down to the Isthmus, and I do not believe that it is feasible for anybody to predict with any great certainty how long a time it will take to excavate the foundations and prepare them for those great locks, send down all the cement and machinery and the various classes of materials, and put them together, under existing conditions on the Isthmus, and so complete the work. That kind of an estimate of time is involved in very great doubt. I think that nine years is about as scant a time as it would be permissible to estimate for that plan. I think it is more likely to run into ten or eleven. Indeed, I should expect, if the construction of this minority lock plan were undertaken, that it would be fortunate if the entire work were completed in less than ten years.

Senator TALIAFERRO. The minority estimated about six and a half.

Mr. BURR. Oh, no; the minority estimates nine, I think—from eight to nine.

Senator MORGAN. Mr. Burr, in speaking of the simplicity of this labor, do you refer to labor with machines or labor with picks and shovels and wheelbarrows?

Mr. BURR. I refer to the general work of excavating the Culebra cut and taking away the spoil. It is a fundamental principle, which I think must be accepted and acted upon by anyone who does any large amount of work on the Isthmus, to use power and machinery to the greatest possible extent and manual labor to the least possible extent.

Senator MORGAN. The work that you expect to be done there will be perhaps 80 per cent of it done with machinery?

Mr. BURR. I should say fully 80 per cent; perhaps more.

Senator MORGAN. It requires really intelligent labor, if not skilled labor, to work those machines, does it not?

Mr. BURR. Yes.

Senator MORGAN. So that in order to get the labor that you need there you would have to go to a pretty high class of operatives or workmen?

Mr. BURR. Yes; those must be mainly obtained from the United States.

Senator MORGAN. Now, that is really the point that I have been distressed about. I want to know whether, for such labor as is requisite to carry this canal through in a reasonable time (the time that you have been stating, for instance), we should go to Martinique or Jamaica and get negroes, or anywhere else, for a very low grade of work. Is it requisite?

Mr. BURR. I think, Senator, that it is. I think it may be requisite even to try the Japanese and Chinese coolies.

Senator MORGAN. They are very much more intelligent laborers than the negroes, I suppose.

Mr. BURR. I imagine they are. I have never had experience with them, but I imagine they are.

Senator MORGAN. But the higher the class of labor you can get there the quicker you will get it through?

Mr. BURR. Yes; of course the more efficient your labor force is the quicker it will be done.

Senator MORGAN. Yes. Do you think that the reliance upon Jamaica labor and Martinique labor and the like, such classifications

of labor as you get from there, is a safe one for digging that canal, or had we better look somewhere for a higher grade of labor?

Mr. BURR. I think it is perfectly safe and good policy to get as much of that labor as you can; but I think this, Senator, that there must be on the Isthmus a surplusage of labor. Otherwise we will have interminable strikes and everything in the nature of a strike. Those laborers, of course, have never been accustomed to anything like a sense of moral obligation, or anything that approaches it, and they will work for two or three days or a week, until they can get money enough to live another week and drink what they want and then cease work until the money is gone.

Senator MORGAN. Let me ask this question then: You speak of strikes and they have been oftentimes mentioned here. You do not mean organized labor strikes or anything like that?

Mr. BURR. There have not been highly organized labor strikes yet, but doubtless there will be in time.

Senator MORGAN. Are these strikes that you refer to attributable to the individual action of the laborer or is it by combination and conspiracy?

Mr. BURR. It is by concerted action.

Senator MORGAN. Concerted action?

Mr. BURR. There is more or less organization, or has been on some occasions, but of course not to any such extent as we have here. But that will come a little later, you can depend upon it.

Senator MORGAN. It will come?

Mr. BURR. Surely.

Senator MORGAN. Now, there is the point. Is it not necessary to have some power of control there for the keeping of men at work in addition to a mere surplus of numbers to which you can appeal or from which you can draw as occasion may require?

Mr. BURR. Those people must be treated with absolute justice; that goes without saying.

Senator MORGAN. That is the first thing; yes.

Mr. BURR. That goes without saying. But after that it is my judgment that there has not been sufficient firmness in dealing with them. I think that we should get much better results if a firmer stand were taken.

Senator MORGAN. Then you want a strong governmental power there to treat them with that degree of firmness which is adequate to the situation?

Mr. BURR. I believe that would be wise.

Senator MORGAN. That is what I think. I will pass that over now. I just wanted to get it on the record as we went along.

Senator TALIAFERRO. The minority estimates that nine years will be required for the lock canal?

Mr. BURR. Yes.

Senator TALIAFERRO. And fifteen for the sea-level canal?

Mr. BURR. Yes; that is natural; but I differ most radically from the minority judgment. I do not believe that it is worth while to see too many lions in the way; and lions are at the basis of the fifteen-year estimate, and the twenty-year estimate, and the various other speculative estimates that we hear so much about. After having set forth a rational and reasonable programme of work, to have that met by no other argument than "Well, there is great un-

certainly about all those elements of the question, and nobody can tell whether they will come out right or not, and consequently the situation is too formidable to lend itself to exact analysis and exact treatment in that manner" is not conclusive.

The CHAIRMAN. That would apply to either plan, would it not, Mr. Burr?

Mr. BURR. It would apply to either.

Senator MORGAN. In your judgment, would there be any real difficulty in getting contractors to do that work by sections, or to take the entire job, and bond them up with a proper security for the completion of the work within the time required and in the way required?

Mr. BURR. I think not. I am not yet sure that it is the best way to treat all portions of the work by contract.

Senator MORGAN. Not every portion?

Mr. BURR. I am not certain yet; I might come to that conclusion later on.

Senator MORGAN. I will take it by the subdivisions that we have been referring to. I will take first the dredging from the seacoast into Bas Obispo.

Mr. BURR. Yes.

Senator MORGAN. Would it be proper and convenient, in your opinion, to have that done by contract?

Mr. BURR. I think that could be done very well by contract. I believe that the Government should do enough of that work itself to establish what would be a reasonable price to pay a contractor for it.

Senator MORGAN. They ought to know that before they go into it, ought they not?

Mr. BURR. But that can not be determined without actual trial. You have to investigate those things.

Senator MORGAN. But if you are making a contract you have to make it upon a unit basis.

Mr. BURR. I know; but let us establish first what will be a reasonable unit basis and then open it to competition and see whether any of these competitive prices are reasonable.

Senator MORGAN. I supposed from all that had been said here that that was what we had been working for for a year and a half—to try to find out what the unit price ought to be.

Mr. BURR. That was the intention, and that was one of the lines of work which was entered upon in the first year of this Commission's existence; but some portions of that have been suspended since then.

Senator MORGAN. Both the majority and the minority have agreed upon these unit prices for each description of work, as I understand it?

Mr. BURR. They have.

Senator MORGAN. That being settled—having the unit prices settled—why can they not be adopted in making up the specifications of contracts with contractors?

Mr. BURR. I can assure you, Senator, that if you are willing to give to contractors the unit prices which were adopted by the board for the purposes of its estimate, you will have no trouble in finding plenty of contractors to do that work.

Senator MORGAN. That is what I supposed.

Mr. BURR. I should be glad to take some contracts myself on that basis.

Senator MORGAN. Now, what are the exceptional parts of the work that you still think ought to be done by the Government?

Mr. BURR. I do not say that I think any large portion ought to be done by the Government, but I say that I have not yet come to a conclusion as to which would be the best. The Culebra cut, for instance, is one.

Senator TALIAFERRO. I think you stated this morning that you thought these unit prices had been fixed in some cases too high?

Mr. BURR. I did.

Senator MORGAN. And agreed to by the majority and minority as reasonable unit prices—very good. That being ascertained, I thought the basis was laid for entering upon a contractual system, unless there is some material objection to it which I have never yet discovered, and that we could go on upon these unit prices and make a contract, if that was considered to be the best way to do it.

Mr. BURR. I think you can do much better than those prices, Senator.

Senator MORGAN. And there would remain to the Government but inspection and supervision and direction in the matter of the executing of the work?

Mr. BURR. Yes.

Senator MORGAN. I was about to ask you whether the controlling works at Gamboa that you have described here would be a part of the work that the Government ought to keep under its own control?

Mr. BURR. I think those, too, could be done by contract to greater advantage.

Senator MORGAN. I do not see that there is anything left open, then, where the advantage would be in favor of having work done by the Government.

Mr. BURR. I think the Culebra cut, Senator, is the point about which there may yet be some reasonable doubt, although my mind is open. I have no positive judgment about that yet.

Senator MORGAN. I would suggest that it is very important that all doubts should be removed, if possible, from the proposition to do this work by contract. All doubts should be removed by study of the subjects, so that the Government can adopt either the present plan of working it out itself, or turn the work over to competent and well-bonded contractors to do it within a specified time and in a certain way.

Mr. BURR. I think it probably will result that the entire work can best be done by contract. I think that is probably what will be found.

Senator MORGAN. This committee will have to make a recommendation upon that subject, I judge; and I was merely trying to get the subject as clear as possible from all doubt and difficulty as to making contracts for completing this work. That is all I was trying to do.

Senator KITTREDGE. I move that the committee adjourn.

(The committee thereupon adjourned until to-morrow, Friday, March 9, 1906, at 10.30 o'clock a. m.)

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Friday, March 9, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Ankeny, Morgan, Taliaferro, and Simmons.

STATEMENT OF WILLIAM H. BURR, ESQ.—Continued.

Senator MORGAN. I would like to ask you, Mr. Burr, whether the Consulting Board agreed upon a unit value—a unit price—for Portland cement?

Mr. BURR. No; it agreed upon a unit price for concrete in place.

Senator MORGAN. What was the unit price? Do you remember?

Mr. BURR. Eight dollars per yard.

Senator MORGAN. Per cubic yard?

Mr. BURR. Per cubic yard; yes.

Senator MORGAN. What proportion of a cubic yard of concrete would consist of Portland cement?

Mr. BURR. You can say, roughly, a barrel to the yard.

Senator MORGAN. A barrel to the yard?

Mr. BURR. Yes. It would probably be a little more than that in some cases, but that is pretty near it.

Senator MORGAN. I suppose Portland cement made according to the usual chemical formula is the cement that would naturally be adopted by the engineers constructing the work?

Mr. BURR. Oh, without doubt—Portland cement and nothing else.

Senator MORGAN. That is a settled proposition?

Mr. BURR. Yes.

Senator MORGAN. It is constructed after a chemical formula that is unvarying, except, perhaps—

Mr. BURR. Oh, to a small extent.

Senator MORGAN. Four or 5 per cent?

Mr. BURR. Something of that sort; yes.

Senator MORGAN. The cubic measurement of the concrete, for instance, in the dam as it is proposed by the majority of the Board of Consulting Engineers at Gamboa would be a very large amount, would it not?

Mr. BURR. If it were built of concrete it would.

Senator MORGAN. Yes.

Mr. BURR. You must remember, Senator, that the majority did not make a definite recommendation as to the type of the Gamboa dam,

but said that it might be built either as concrete masonry or as a great earth dam with a masonry core.

Senator MORGAN. I supposed that all question as to the actual type of any dam or structure would be left open for consideration by the engineers.

Mr. BURR. Precisely.

Senator MORGAN. To be determined by them rather than by the act of Congress.

Mr. BURR. Precisely.

Senator MORGAN. Now, a still greater amount of Portland cement or of concrete would be necessary, I suppose, in the event of the construction of a dam at Gatun?

Mr. BURR. No; the plan of the Gatun dam—that is, of the dam proper—requires no cement. That is, it is simply a great mound of earth. But the locks, and the appurtenances to the locks, and the waste weir would, of course, involve great quantities of cement.

Senator MORGAN. Quite equal to the dam at Gamboa?

Mr. BURR. Probably more. I think that the total quantity of concrete that would be required by the minority plan would not be far from 3,500,000 cubic yards. I do not mention that as exact, but it is pretty close to it.

Senator MORGAN. Yes.

Mr. BURR. So that, roughly speaking, there would be about 3,500,000 barrels of cement required.

Senator MORGAN. That was all I wanted to know.

The CHAIRMAN. Is that at Gamboa alone?

Mr. BURR. No; that, Senator, is for the lock plan.

The CHAIRMAN. For the entire lock plan?

Mr. BURR. For the entire lock plan; yes.

The CHAIRMAN. I thought Senator Morgan was going to ask you a question there which I will ask you. Is Portland cement, whether you get it from one place or another, almost uniform in the matter of quality?

Mr. BURR. Very nearly so, from first-class manufacturers. The chemical formula varies somewhat; but in the main features it is the same.

The CHAIRMAN. Does it vary enough to make it a mistake to put in different kinds—that is, from different manufacturers?

Mr. BURR. You would not mix the cement from different manufacturers before using it in concrete. I do not know that there would be any special objection to that, but it would be an experiment, and there is no need of following that procedure.

The CHAIRMAN. If you were going to build a dam, say, at Gatun, or the locks at Gatun, you would use the same cement, would you, from the same manufacturer?

Mr. BURR. Not necessarily. You might use half a dozen different brands on that one work, but you would use each brand by itself.

The CHAIRMAN. The result would be all right?

Mr. BURR. The result would be all right; yes.

Senator MORGAN. But if you could get the entire supply of cement, for instance, for the Gatun dam, from one establishment, to be delivered by that establishment as required, for the sake of uniformity and for the sake of security in that uniformity of strength, it would be advantageous to have it, would it not?

Mr. BURR. Not materially so, Senator. There is not difference enough. All the cement used would be tested and its quality found and approved. There is not as much difference between brands of cement of first-class manufacturers as you are likely to get in the continued product of a single maker. It is not all absolutely uniform and mathematically unvarying. For instance, I had occasion to use cement last year from one of the oldest and most reliable firms in this country—a firm whose cement has been used by the million barrels about New York—and yet part of that cement would take its initial set, as we say—that is, its first degree of hardness—in an hour and a half, about as it ought to, and other parts in nine hours. That, of course, is abnormal. That raised a question as to the propriety of using the cement, but still that illustrates what you may get from even the best of makers.

Senator MORGAN. Such a variation of time in the initial setting of the cement would be a serious difficulty, would it not—a serious objection?

Mr. BURR. No; not unless it was for some special under-water work and where it was desirable to get the cement hardened as quickly as practicable.

Senator MORGAN. That is exactly what I refer to.

Mr. BURR. These locks, however, would not be built under water; they would be built in the dry.

Senator MORGAN. No; but the dams would be built under water?

Mr. BURR. No, no; all the work on the dams would be built in the dry also.

Senator MORGAN. In the dry?

Mr. BURR. In the dry, as we say—that is, it would be in great trenches in special inclosures where the work would be done in the open air, or, as we say, in the dry. Whatever water would come into these inclosures would be pumped out. No; none of that would be under-water work.

Senator MORGAN. Do you understand that in the construction of the Gatun dam, as proposed by the minority of the consulting engineers, that waste way of the controlling works would be built on dry surfaces?

Mr. BURR. In the dry; it would be built wholly in the dry.

Senator MORGAN. You would have to exclude all of that water?

Mr. BURR. Yes; the flow of the river must be controlled so that that end can be accomplished.

Senator MORGAN. By "the dry," you mean that there must not be any settled pool of water?

Mr. BURR. I mean that the fresh concrete that is put in, the fresh masonry, is not covered by water. There may be water around it. There may be a wet place; but the fresh masonry is not covered by water.

Senator MORGAN. And after it has set, then it may be covered?

Mr. BURR. Then it may be covered by water.

Senator MORGAN. And it gets harder as time elapses?

Mr. BURR. It gets harder as time elapses.

Senator MORGAN. Provided the cement is right?

Mr. BURR. Yes.

The CHAIRMAN. Do I understand that the cements that set in an hour and a half and those that set in nine hours are equally good, Mr. Burr?

Mr. BURR. That does not always hold, but it was so in that particular case; they were equally good.

Senator MORGAN. Was this cement that you speak of made in the Lehigh Valley?

Mr. BURR. It was made in the Lehigh Valley. It was Giant Cement—one of the most reliable brands made in America; a most excellent cement.

Senator MORGAN. In buying the Lehigh Valley cement in the work that you speak of, what was the average price per barrel—the fixed price per barrel?

Mr. BURR. I said it was last year; it was really year before last.

Senator MORGAN. Yes.

Mr. BURR. It was \$1.30 a barrel, delivered up in Connecticut, where I used it.

Senator MORGAN. \$1.30?

Mr. BURR. One dollar and thirty cents, in bags.

Senator MORGAN. Yes; in bags. They call it "barrels," but they do not use barrels?

Mr. BURR. No; there are four bags to a barrel. They will supply it in barrels, of course, but it is more economical to get it in bags.

Senator MORGAN. As a rule, how long will a bag of good Portland cement continue to be altogether the thing you want, as to atmospheric conditions and transportation by water and the like?

Mr. BURR. You can keep it indefinitely if you keep it dry. If you put it in a case that will keep it dry, that will keep the moisture out, I do not know why you should not be able to keep it indefinitely. Of course, under ordinary circumstances a little moisture finds its way in, but still there is no difficulty in keeping cement several months without special precautions, if you simply keep it in a dry place, covered up.

The CHAIRMAN. Have you ever used cement manufactured by the Association of American Portland Cement Manufacturers, of Philadelphia?

Mr. BURR. I imagine that that is an organization of manufacturers.

The CHAIRMAN. I suppose it is a combination of manufacturers.

Mr. BURR. Yes.

Senator MORGAN. There are quite a large number of manufacturers of cement in the United States, large and small, are there not?

Mr. BURR. A large number, and a large number of first-class makers, too. There is no better cement made in the world than is made in this country at the present time. There are a dozen different makers, perhaps more, the products of whose mills are first class.

Senator MORGAN. I notice that Mr. Ross mentioned vouchers that had been prepared for imported cement. Do you know anything about why that cement was imported?

Mr. BURR. I do not know of any other reason—I do not know of that particular case at all, but I presume that he can get foreign cement delivered at Panama at such a price as will compete successfully with American cement delivered there, and that is probably the reason for that particular incident.

Senator MORGAN. I suppose that after this canal is completed there will be a very great demand for cement on the western coast of America—North and South America?

Mr. BURR. Oh, I think so, without any question. The use of Portland cement is extending with amazing rapidity and has been for the last ten years—remarkably so.

Senator MORGAN. The coast that I speak of—the Pacific coast of America, commencing up at Alaska and going down to the Horn—is not productive in cements, it appears?

Mr. BURR. I do not know about that, Senator. It was not supposed twenty years ago that this country could afford raw materials for Portland cements. It was not thought practicable or possible. Of course now we have it on all sides, and it may turn out—and I think it is quite likely to turn out—in the same way on the Pacific coast, that materials will be found that are suitable for the production of excellent Portland cement.

Senator MORGAN. Would you expect to be able to get a supply of Portland cement from the Panama Zone?

Mr. BURR. I believe that there is raw material there, whether in the Zone or out of it, but within the limits of the Republic of Panama, which will make excellent Portland cement.

Senator MORGAN. But the transportation of the coal required to burn it would make it costly, would it not?

Mr. BURR. That may be a serious element. It may also be that coal will be found right on the ground. There are parties exploiting coal mines at present, you know, within a few miles of the canal line, and it is possible that that question of fuel will solve itself right on the spot.

Senator MORGAN. Is that the old Chiriqui development of coal, in the Chiriqui region?

Mr. BURR. It is up in the Chiriqui region, near Bocas del Toro. In fact, it is right in there; it is right adjacent to Bocas del Toro.

Senator MORGAN. That is the coal field the United States has been trying to get possession of for many years, you know.

Mr. BURR. Yes; but there is coal nearer to the Canal Zone than that. There is quite a considerable amount of coal up the Indio River, within, probably, 10 or 15 miles of the canal line; but whether it is good enough to have any commercial value has not yet been determined.

Senator MORGAN. That is to the west of the canal?

Mr. BURR. That is to the west of the canal.

Senator MORGAN. Is there any to the east that you have heard of?

Mr. BURR. Not that I have heard of; but, then, you know the mineral resources of that country have not been investigated.

Senator MORGAN. No; I suppose they have not been.

Mr. BURR. Not to any sensible extent; so that there is no telling what will be found there.

Senator MORGAN. I am afraid they will find gold there, and if they do they will tear the canal up to dig it out of the bosom of the earth. [Laughter.]

Senator KITTREDGE. As we were adjourning last night, Mr. Burr, as I recollect, you were talking of the question of the work being done by contract.

Mr. BURR. Yes.

Senator KITTREDGE. Had you completed what you wished to say on that subject?

Mr. BURR. Practically so. I stated that my conclusions had not yet taken very positive shape as to doing the Culebra work by contract, although I think that it will undoubtedly come around to that—that is, that it will be advisable to do even the Culebra work by contract. My only reason for putting the matter in that qualified way is that I should like to have seen much more work of investigation by the steam shovels, so as to determine a reasonable price for that work before the contracts are let.

Senator KITTREDGE. Do you mean in the wet season?

Mr. BURR. I mean both in the wet and dry seasons—right through the year. Even though those investigations might have been carried on under very disadvantageous conditions, I believe that we should have learned a great deal that is valuable. You will probably all remember that during the first year of the existence of the Commission a large amount of that investigation work was done and was productive of valuable results; but during the past six or eight months that work has been suspended entirely, so that we have ceased to get the benefit of that kind of an investigation. I believe that it will undoubtedly prove to be advantageous to do the whole work by contract.

Senator MORGAN. I was thinking about that after we had some talk about it yesterday evening. You divide (properly, as I suppose) the Culebra cut between Obispo and Miraflores. That is practically the Culebra cut?

Mr. BURR. That is practically the Culebra cut.

Senator MORGAN. Very good. Now, the great difficulty in that cut, if I understand it, is the transportation of the spoil?

Mr. BURR. It is a great transportation problem; that is the whole thing.

Senator MORGAN. Yes. Now, of course, as the Government owns the railroad and operates the railroad, it would have to supply transportation to the contractor. It could not give up the railroad and let him control it?

Mr. BURR. Oh, no.

Senator MORGAN. Very good. The Government, then, would have to supply transportation for the contractor in that particular part of the work?

Mr. BURR. That would probably be the way in which it would have to be done.

Senator MORGAN. Therefore that contract would be differentiated from, perhaps, any great part of the work by the fact that the Government would have to supply the transportation? That is what I supposed to be the difference between the Culebra cut, as we call it, and any other part of the construction.

Mr. BURR. Yes; that is a differentiating feature, and a great differentiating feature.

Senator MORGAN. Yes. Now, then, as a proposition that would be general in its application to the work of construction of that canal, the Government ought to retain the control of all the transportation by land?

Mr. BURR. I think it should.

Senator MORGAN. Yes. Of course if you come in with dredges from the Bay of Limon and proceed to dredge the canal up as far as

Gamboa, as far as you want to go with it, that transportation would be barge transportation and pipe-line transportation?

Mr. BURR. Entirely so.

Senator MORGAN. You would not have any occasion, or very little occasion, perhaps, for the use of the railroad in order to get rid of the spoil that might come out of that part of the canal between the Bay of Limon and, say, Obispo?

Mr. BURR. That might not hold, Senator, as far as Obispo. It certainly would hold as far as Bohio.

Senator MORGAN. I know it would.

Mr. BURR. Between Bohio and Obispo there would probably be a considerable amount of excavation in the dry, and that spoil would have to be carried away by rail.

Senator MORGAN. Then, if I understand you, the control of the railroad for the transportation of all the spoil that has to be transported by rail would be necessarily retained in the hands of the Government?

Mr. BURR. That is my judgment.

Senator MORGAN. Yes; and that would harmonize with the transportation for commercial purposes?

Mr. BURR. Yes.

Senator DRYDEN. You may have explained, perhaps, when I was not here, whether it is your idea that this canal shall be divided up into sections for contract work?

Mr. BURR. I think it should be, Senator.

Senator DRYDEN. Have you formed an opinion as to how many divisions there should be?

Mr. BURR. I do not wish to express myself positively upon that matter, but I should say generally that there will be a dredging section from Colon (including, perhaps, the harbor work) to Bohio. That is all dredging work of a practically uniform character. The breakwaters in Colon Harbor or Cristobal Harbor, whichever you choose to call it, might or might not be by separate contract. Then there would also be a section from Miraflores to the Pacific Ocean which could be done by a separate contract. The Gamboa dam—I am now speaking of a sea-level plan—would, I think, be a separate section or contract. The Culebra cut would probably be another, and the work from Bohio up to Obispo possibly another—some such division as that.

Senator DRYDEN. That would be, with a sea-level plan, something like seven different contracts?

Mr. BURR. Something like that; yes.

Senator MORGAN. Each of these divisions you speak of has its own characteristics that will have to be provided for in specifications?

Mr. BURR. Precisely.

Senator TALIAFERRO. Except the two dredging contracts—the one from the Atlantic and the other from the Pacific ends?

Mr. BURR. They might go under one contract. In fact, the same parties might take two of these sections, possibly; but I mean that would be approximately the general division of things.

Senator TALIAFERRO. If the canal were to be built by contract, would you not consider it advisable to get as much of the work under the management of one contractor as possible?

Mr. BURR. I think that as a general principle that would be advisable, but just how far that should be carried in covering two or more of these approximate sections which I have mentioned would be a matter to be determined when it arose; that is, I should not like to put myself in the position of making a very positive statement as to those details at this stage of the matter.

Senator KITTREDGE. Undoubtedly if the work is to be done by contract, bids would be invited upon each section and the entire work?

Mr. BURR. Probably.

Senator KITTREDGE. Or a different combination of sections?

Mr. BURR. Yes.

Senator KITTREDGE. Would it be done in that way?

Mr. BURR. It could be done in that way and probably would be, or in some similar way.

Senator DRYDEN. In many contracts where different contractors are interested and contract for the different parts of the construction one contractor may either help or hinder very materially the work of another contractor. I am speaking now of the general, ordinary contract work. Would that be applicable in this work?

Mr. BURR. It might be.

Senator TALLAFERRO. Would it not be peculiarly applicable in this work, in view of the fact that we have only the one railroad there, the Government line, and in view of the difficulty about the labor conditions on the Isthmus?

Mr. BURR. If the Government controlled the railroad—and that is one reason why it should, in my judgment—that fact would obviate a good deal of this intercontract friction which would or might otherwise take place. But, for instance, if the Gamboa dam should be a great earth mound with a concrete core, and that earth should be taken from the Culebra cut and there should be two different contractors for those two portions of the work, unless the specifications were carefully drawn and the whole management efficient you can readily see that those two contractors might have considerable friction about various points in the progress of their works. But under efficient management it might be practically eliminated.

Senator TALLAFERRO. What would be the length of the haul from the Culebra cut to the Gamboa dam?

Mr. BURR. It would depend upon the portion of the Culebra cut from which you took the material to the bank. From Gamboa to the highest point of Culebra Hill is about 6 miles, along the canal line; but from Gamboa to the beginning of the deepest part, at Las Cascadas, is only 2 miles. It would not be a long haul.

Senator MORGAN. Is that at Obispo?

Mr. BURR. Las Cascadas is near Obispo. Obispo is about halfway between Las Cascadas and Gamboa.

Senator MORGAN. The proposition grows upon me that you seemed to subscribe to yesterday—that in any and every event the United States will require the exercise of its strongest and even its most arbitrary powers down there to control situations, and particularly so if you put it in the hands of contractors.

Mr. BURR. I do not know that I should want to subscribe at once to the expression "the most arbitrary power," but there certainly must be a firm control of the situation.

Senator MORGAN. I mean a power least controlled by writs of habeas corpus and lawsuits of different kinds, and interventions, appeals, etc. I will say "summary" instead of "arbitrary."

Mr. BURR. I have no hesitation in saying that there must be a very firm control of things down there; but as to the details of procedure in order to secure that control I should prefer not to express myself very positively.

Senator MORGAN. But you are satisfied that the power ought to be there to control it?

Mr. BURR. There should be a firm control of the whole situation; there is no question about that, in my judgment.

Senator TALIAFERRO. Mr. Burr, you addressed yourself yesterday with some particularity to the time it would require to put a ship through this lock canal. Did you state, or will you state now, concisely, what time you estimate it would take the ordinary ship to pass through the seal-level canal from ocean to ocean?

Mr. BURR. It would depend somewhat on the size of the vessel; in fact, it would depend a great deal on the size of the vessel.

A ship 800 feet long, we will say, such as is now building (which, of course, is an enormous vessel, and larger than any now afloat), would require probably ten hours, with the prism proposed in the majority report. A ship, say, of 5,000 tons burden, such as at present the New York and Hawaiian Steamship Company are running between New York and San Francisco and New York and Hawaii, would pass through that canal in probably six hours—six or seven. Ships have passed through the Suez Canal (and that, after all, is the only practical test which we have at the present time as to such matters), a canal with a materially smaller prism, at the rate of about 6 miles an hour, when their wetted section has been almost one-third of the wetted section of the canal prism; whereas the majority has based its considerations of passing through the sea-level canal on the wetted cross section of a ship being not more than one-fourth of the wetted section of the canal prism.

Those are facts of experience on the Suez Canal with ships up to nearly 600 feet in length—not quite. I think they have passed ships up to 560 feet in length, but, so far as I now recall, not up to 600 feet.

Senator MORGAN. Do they run day and night?

Mr. BURR. They run day and night.

Senator KITTREDGE. How about the passage of the same ship through the lock canal?

Mr. BURR. That brings up the same question which I touched upon yesterday. It is essentially impossible to estimate, under practical conditions, the time required to pass such a ship through the lock canal on the plan of the minority. We may assume, as is assumed in the minority report, that the ship arrives at the terminal port when the condition is exactly right for its immediate entrance into the canal; that all of the enormous machinery of these six locks is working to perfection; that the ship will move promptly to its place in the lock; that the gates behind it will be closed without a hitch and that those in front of it will be opened without a hitch; that the filling and emptying of the locks will all occur promptly; that everything in this train of appliances and its management and con-

trol shall fit exactly into each other—that is, with absolutely ideal conditions you might get such a ship through the lock canal in perhaps eight to nine hours.

But when you take the average time in the long run, month in and month out, with ships arriving at the terminal harbors practically in fleets, the last of a fleet of ships would naturally have to wait until all the others had gone into the locks and passed on their way.

Senator TALIAFERRO. Mr. Burr, let me interrupt you there a moment. Does that estimate of time refer to the 800-foot ship—the ship 800 feet long—or to the average ship?

Mr. BURR. I am now speaking of the average ship, 400 or 500 feet only in length, or less, if you please.

Senator TALIAFERRO. So that the difference of time between the sea-level and the lock canal for the passage of the average sized ships would be what?

Mr. BURR. I am getting at that as nearly as I can. The last of those half dozen ships, we will say, would probably have to wait at the terminal harbor some eight or nine or ten hours, even if everything worked to perfection—and it never does with human things. But suppose it does work to perfection, then the average wait or delay of those ships at the terminal would be perhaps four hours. It might easily be more than that, but say it is only four hours. Now, add that to the time required in actual ideal passage, and you would get from twelve to thirteen hours—materially more than would be required to pass through the sea-level canal.

If you add to that (which you must add if you are to deal with things as they actually are and not theoretically) the hitches of machinery and lock gates and the little delays of all kinds that will occur in the operation of such trains of mechanism and so many heavy moving masses, with an occasional breakdown or accident, either to the ship or to the lock or to something else, I doubt very much whether the average through the year of the time of passage of a ship through the lock canal will be less than twice that required to pass a ship through the sea-level canal. Of course that is not an exact computation, but it is as near as can be made.

Senator KITTREDGE. Right at that point, Mr. Burr, let me suggest that I notice that in the minority report a comparison is made with conditions at the Soo lock. Have you any comment to make upon that suggestion or statement?

Mr. BURR. I am very glad that you have asked that question, Senator, for I had intended to touch upon that matter before and it has slipped my mind.

Any conclusion as to the time of passing through the canal on this lock plan with six great locks, three of them being in series at the Gatun dam, based upon the experience at the Soo, with one lock only. and that with only about two-thirds the lift of any one of these, will be utterly misleading, and I want to say that with all earnestness and emphasis, because that fact is frequently overlooked. The majority has stated it, but it has not received the attention to which its actual importance entitles it.

The passage of traffic through the St. Marys River and the Soo lock—because, strictly speaking, there is no canal there; the canal is only a mile and three-fifths long, and it is practically an approach to

the lock and nothing else—is made under conditions radically different from those which will be found at the Isthmus for all time. All the ships that pass the Soo lock pass it practically on schedule time. That service has been aptly termed a ferry. They are ships running between the Lake ports, from the Lake ports this side of the Soo to Lake ports the other side, or vice versa. There is a regular procession of vessels—that is what it amounts to—with fixed intervals between them, or, as I said a few moments ago, practically running on schedule time. It is precisely like a railroad schedule. That is not an exaggeration. It is simply a statement of the facts as they are. Now, that is ideal for that purpose, so that it is rare that two or three ships will conflict with each other under such circumstances.

Anyone who is familiar with ocean navigation, I think, in any port of the world, will bear me out in saying that no such regularity of traffic is thinkable.

Senator KITTREDGE. You are now speaking of the lock plan?

Mr. BURR. I am now speaking of the traffic which will be tributary to the isthmian canal. I have just shown with what schedule regularity ships approach and pass through the Soo lock, and I am now contrasting it with the conditions which will exist at the Isthmus.

Of course no such regularity of schedule as that is possible. The ships in the interior lakes pass over trips of a few hundred miles at most between ports. The ships that will pass through the isthmian canal are engaged in ocean navigation. They come from ports all over the world, going to ports all over other parts of the world. French, German, Italian, English ships are going to the Orient, we will say, or American ships are leaving the Atlantic coast to go to the Orient or the Pacific coast of the United States or in other directions; and it is the experience of every port in the world (it must necessarily be so) that there is no regularity in the arrival of ships at a terminal canal port under such circumstances. There may be a day or two with scarcely a ship and then a day with a dozen. It is very misleading to state any conclusions as to time of passage, or, in fact, any other conclusions as to the operation of the lock plan at the Isthmus, on the experience of the Soo lock. This bunching of ships on the Isthmus, or arriving in fleets, as I stated yesterday, if the traffic ever becomes great, as, in my judgment, it certainly will, would result in most confused congestion with a lock canal. In fact, if you attempt to analyze it on a theoretical basis, you will find that some ships will never get through the canal.

The CHAIRMAN. Mr. Burr, have you gone over the statement made by the chief engineer in regard to that particular?

Mr. BURR. I have.

The CHAIRMAN. Will you give us your opinion as to his statement?

Mr. BURR. You mean—

The CHAIRMAN. As to the time he thinks it will take, in his letter, generally, in regard to that.

Mr. BURR. He takes the same position as the minority.

The CHAIRMAN. I understood you were going to talk to us this morning in reference to Mr. Stevens's letter, were you not?

Mr. BURR. Yes; and I shall, in detail; but as to this particular point regarding the time of passage through the canal, his position is

the same as that of the minority, and my criticisms of the minority's position apply directly to his observations. His statement to the effect that ships can pass through the lock canal quicker and more safely than through a sea-level canal is, in my judgment, without any foundation whatever in actual experience.

Senator MORGAN. Mr. Burr, you have mentioned your opinion that the traffic through the canal will become very great, very much greater than is now supposed by people usually, I take it?

Mr. BURR. I believe it will become a large traffic.

Senator MORGAN. The traffic through the Suez Canal has increased very rapidly, has it not?

Mr. BURR. It has.

Senator MORGAN. The traffic through the Soo Canal has increased with still more wonderful rapidity?

Mr. BURR. Still more wonderful rapidity.

Senator MORGAN. Yes; so that the tendency of commercial intercourse and interchange has been very active and is getting more and more so every day?

Mr. BURR. It appears to be.

Senator MORGAN. I suppose that no one could now estimate what amount of commerce would await transportation through the Panama Canal at the time of its being completed either on the sea-level plan or the lock plan? No one can make any estimate as to that?

Mr. BURR. No; nothing like a demonstrable conclusion. The Commission of 1899-1901 made as careful a study of that question as could be made, and it did not express any positive opinion, but thought that there might be seven or eight million tons, or something of that sort.

Senator MORGAN. And there are just as apt to be seventeen or eighteen million?

Mr. BURR. Yes; or, the first year, less.

Senator MORGAN. So that the capacity of the canal is limited to a certain amount of tonnage passing through under the best system of management. It is a limited capacity.

Mr. BURR. The lock canal is of limited capacity; but a sea-level canal—of course its capacity is limited, too, but its limit is so high that it is very great.

Senator MORGAN. I had supposed that the sea gate on the Panama side was a limit of a very important character.

Mr. BURR. I do not think that it is a very serious limit, Senator, for the reason that if at one stage of the tide there were half a dozen ships waiting to get into the canal—just as I have supposed already—within that tide there would come a period of a considerable number of hours when the gates would be wide open, and the whole could go through.

Senator MORGAN. If, instead of seven or eight millions of tons—which have been the basis of calculation passing through annually—there should be seventeen or eighteen million tons, then you would think that the canal was about to its limit, would you not?

Mr. BURR. No; I think that the lock canal would pass more than that. There would be great inconvenience at times, but I think it might pass, perhaps, thirty or thirty-five millions. But you can not estimate that with any reliability.

Senator MORGAN. The Soo Canal already passes 36,000,000 annually in half the year, does it not?

Mr. BURR. At that rate?

Senator MORGAN. Yes.

Mr. BURR. At that rate?

Senator MORGAN. Is that only at the rate of 36,000,000?

Mr. BURR. It operates approximately only eight months in the year, but it is at that rate.

Senator MORGAN. But the 36,000,000 actually went through it last year, did they not?

Mr. BURR. I think it is not quite so much as that.

Senator MORGAN. Well, thirty-five or thirty-six—close to it.

Mr. BURR. As I recall it—I may be mistaken, but as I recall it—the rate during the eight months of its use was at about 39,000,000 tons in twelve months.

Senator MORGAN. Yes.

Mr. BURR. But I may be mistaken about that. It was a large quantity.

Senator MORGAN. It is a tremendous quantity.

Mr. BURR. It is a tremendous traffic; but you must remember that there is only a single lock there, Senator.

Senator MORGAN. And that is supplemented by the British locks in sight of it on the British side of the waters?

Mr. BURR. It is.

Senator MORGAN. And they carry almost an equivalent amount, do they not?

Mr. BURR. No; nowhere near as much. The bulk of the traffic passes on this side.

Senator MORGAN. But it is still supplemented by at least two great trunk lines of railway that haul much of the stuff that would go through the canal if there was no other means of transportation; so that the increase of commerce at that center or along that line has been simply tremendous and almost unaccountable.

The point I want to get at is this: I will state as a predicate for it that my view of the situation, and my doctrine, if you please to call it such, is this—that no government in the world—not even the local governments on that Isthmus—shall be permitted to stand in front of the United States as to the control of any canal cut anywhere through the isthmian region. That is my predicate. Therefore the United States, if it follows out its own declarations and its own indispensable national policy, must take charge of any canal that is carried through there. That does not apply to railroads, but to canals, and very properly; because a railroad can not get out to sea, while a ship passing through a canal can, and can go to the uttermost parts of the earth.

It is further my impression and my conviction that by the time we get the Panama Canal built on either plan we will find more commerce there than one canal can carry, and that the necessary resort will be to the canal through Nicaragua, and then that “the stone which the builders have rejected will become the chief stone of the corner.” That is my notion about it. I do not hesitate at all to speak of it and to state it, because I look forward to it with great hopefulness.

Do you conceive that there may be a necessity, that it is quite reasonable to contemplate a necessity, for having an additional line of canal ready, not only to accommodate the excessive commerce that will present itself for passing through the canal at Panama, but also to accommodate the ships that are sailed by the winds that belong to American commerce? Do you conceive that that is a probability?

Mr. BURR. Senator, you have constructed in a very skillful and graceful way the strongest argument that I could possibly hope for in favor of the sea-level canal at Panama.

Senator MORGAN. I do not think it is an argument against it, by any means.

Mr. BURR. Because a sea-level canal has practically unlimited capacity, and if the canal as completed should be found in any way or for any purpose inadequate for the traffic of future years—as it probably would be at some future time, not so very remote in the future, either—its enlargement to accommodate that increased traffic would be simplicity itself. It could be done economically; it could be done rapidly and most effectively.

Senator MORGAN. Now, will you please state how that can be done, because that is an exceedingly interesting question?

Mr. BURR. It can be done by simply excavating material on one side or on both sides, if you wish—all that part above the water surface in the canal in the dry and the small portion remaining under water.

Senator MORGAN. Right there, if you will allow me, I want to ask you a question. Do you adhere to the same plan in regard to the sea-level canal that was suggested in regard to the plan of the Walker Commission, of putting walls on either side of that canal?

Mr. BURR. As a result of our experience on the Isthmus and of my own personal experience during the past six years—for I have had opportunity to observe that matter closely—I believe that those revetment walls are absolutely unnecessary.

Senator MORGAN. You exclude them, then, from your calculations?

Mr. BURR. I exclude them from my calculations.

Senator MORGAN. I wanted to know how that was.

Mr. BURR. There may be a few soft spots here and there; but that would be a matter of very small moment and is included in the 20 per cent for contingencies.

Senator MORGAN. So that in the enlargement of your canal you would not have to take out any walls?

Mr. BURR. You would take out no walls, reconstruct no expensive masonry; you would simply dig and cart away the material.

Senator TALIAFERRO. And the work, Mr. Burr, could really be done more economically, could it not, by the use of the canal than by digging out the greater width at one time?

Mr. BURR. Much more so. In fact, the whole operation would be one of extreme simplicity and economy; and it would interfere not at all, or at any rate not sensibly, with the navigation through the Isthmus at the time.

Senator MORGAN. So that if it became necessary, in order to accommodate commerce, to enlarge the sea-level canal, you would prefer to do that rather than to build a canal through Nicaragua?

Mr. BURR. I should, Senator; although I have very pleasant recol-

lections of Nicaragua and great admiration for the natural beauties of that route.

Senator MORGAN. And you made a strong recommendation in favor of its practicability on two occasions, once under oath, did you not?

Mr. BURR. I think not on two occasions. We reported first favorably to the Nicaragua route, because it was impossible to get a reasonable proposition from the New Panama Canal Company.

Senator MORGAN. No; that was before you had made up your mind about that, I take it—before you had ever heard of a proposition from the Panama Canal Company.

Mr. BURR. I do not recall what you have reference to, Senator.

Senator MORGAN. I have reference to the fact that you had stated—every one of the Commissioners, if I remember correctly, had stated—under oath before this committee that that plan of the canal through Nicaragua was practicable.

Mr. BURR. It is; I say so now. It is practicable.

Senator MORGAN. Very good.

Mr. BURR. It is feasible.

Senator MORGAN. That is all I wanted to have said.

Senator DRYDEN. Professor, if the sea-level scheme of canal of which you speak should in the future be enlarged, would one result of that enlargement be to take out and to reduce the sharp angles of the canal, so as to make it safer for the vessels going through and reduce the time of passage?

Mr. BURR. The curvature could be eased, but the extremely easy curvature of the present plan is such that there is no danger in passing those curves.

Senator DRYDEN. Then you do not agree with Chief Engineer Stevens that on that plan it would be dangerous to the big vessels going through there?

Mr. BURR. I do not, Senator.

Senator DRYDEN. Perhaps you have covered that ground.

Senator MORGAN. He has been over all of that yesterday.

Senator DRYDEN. I do not wish to ask you about it again, then.

Mr. BURR. I will be very glad to reiterate it, Senator.

Senator DRYDEN. No; I will read it, Professor, in your testimony.

Mr. BURR. The curvature is so gentle, so easy, in the recommended sea-level plan that the experience on the Suez Canal—and we must, I think, come back to that on all these disputed points where we can—shows that there is no difficulty whatever in the rates of speed which we are now considering in passing ships around those curves; and you can pass an 800-foot ship—in fact, you can pass a 1,000-foot ship—through the sea-level prism as recommended with perfect safety. It would be at a lower speed, of course, than a smaller ship.

No; I disagree absolutely with the chief engineer's expression; and I will go even further than that and state that I do not know where he can find any evidence in the practical operation of marine canals which will substantiate his views to the slightest degree.

Senator KITTREDGE. Mr. Burr, while you are on this subject, can you give us the aggregate curvature of the Suez Canal?

Mr. BURR. That was asked for yesterday, and I had forgotten that it is given in detail, but not summed up, here; but I can give you that in just a moment.

Senator KITTREDGE. Yes; and then compare it with the sea-level plan that the Board of Consulting Engineers propose.

Mr. BURR. It is, I think, about 467 degrees; and there is additional curvature in the lakes. In the canal proper, between the terminal harbors and exclusive of the lakes, there is a total curvature of 467 degrees.

Senator KITTREDGE. That is at Suez?

Mr. BURR. That is at Suez; and in the sea-level plan, as proposed by the majority, there is a curvature of about 597 degrees, not a great difference. The curvature of the sea-level plan compares most favorably with that in the Suez Canal.

Senator TALIAFERRO. Mr. Burr, what would be the effect on the lock canal if one or more of those locks were destroyed, blown up?

Mr. BURR. It would simply destroy the canal until they could be rebuilt.

Senator MORGAN. What would be the effect on the sea-level canal if a great ship 800 feet long were sunk in the Culebra stretch?

Mr. BURR. It would block the canal so long as it lay there. In that case it would simply be blown up and gotten out of the way within a few days, just as was done in the Suez Canal three or four months ago. You can do that anywhere in a sea-level canal, but you can not blow up a ship in a lock.

Senator MORGAN. But there is no chance to pass by it while it is lying there?

Mr. BURR. Oh, it would be but a matter of hours, perhaps, to make a passage by in many places, but it would, of course, block the canal for the time being, until either the ship was out of the way or a passage around it made. But the probability is that the same course would be pursued as was pursued in the Suez Canal three or four months ago, when a ship was blown up to get it out of the way.

Senator MORGAN. The rolling of a stone of the magnitude of, say, 20 or 30 cubic feet from these heights down there would block it until that stone was gotten out, would it not?

Mr. BURR. Oh, no.

Senator MORGAN. It would not?

Mr. BURR. In the first place it is not a uniform slope from the top of these great cuts down to the canal. The sides would be finished in benches about 30 feet high and 12 or 13 feet wide on top, or from 12 to 15 feet wide on top. Those would catch any stone that started from any bench. It would simply fall on the terrace immediately below it and remain there. Then there is a berm 50 feet wide on either side of the canal prism at the bottom of the cut, so that it is practically impossible for any incident of that sort to occur.

Senator MORGAN. That berm and those benches would not stop an avalanche of this creeping clay that you speak of, would they?

Mr. BURR. No; if there were any; but there will not be any when the canal is done. That observation applies to either type of canal.

Senator MORGAN. Why?

Mr. BURR. Because that clay is of limited volume, and all that adjacent to the canal will be removed.

Senator MORGAN. Have you taken that into account in your estimates?

Mr. BURR. That is taken into account in both estimates.

Senator MORGAN. The removing of the slipping clay that may come down into the canal?

Mr. BURR. Yes; so that the possibility of that incident is absolutely removed.

Senator TALIAFERRO. You said that the destruction of one or more of those locks would destroy the canal.

Mr. BURR. I mean it would put it out of commission. It would make it impossible to pass traffic. Of course if this accident, which you speak of, destroyed one lock only, completely or not completely, but seriously shattered it, it would let the water out of that level, out of the summit level—in fact, while there would be—

Senator TALIAFERRO. Would the lower locks control the water if the upper lock, for instance, was destroyed?

Mr. BURR. They might; but see what would happen, Senator. Suppose the upper lock—that is, the lock at the extremity of the summit level—should be destroyed. Suppose a ship should run through the gates, and by some fortunate incident save itself from destruction, but knock the gates out. That would immediately draw off the water from the upper level. The gates below that would not have any effect upon the matter, because the water would pour into each lock below and over the tops of the gates or side walls in the shape of a cascade or a cataract.

Senator KITTREDGE. And reduce the summit level of the water?

Mr. BURR. It would drain the summit level.

Senator KITTREDGE. To what extent?

Mr. BURR. It would drain it—that is, down to the level of the bottom of the lock.

The CHAIRMAN. What would be the result if an accident of that kind should happen to the lock in the sea-level canal?

Mr. BURR. If that sort of an accident happened to one of the locks in the sea-level canal it would simply permit the water from the sea to go into the canal at extreme high tide or the water to flow out of the canal in extreme low tide, until the obstacles in the locks had been taken away.

The CHAIRMAN. That would stop all traffic upon the canal, would it not, for the time being?

Mr. BURR. For the time being, until the obstacles were taken away.

The CHAIRMAN. The same as it would in the other canal?

Mr. BURR. Yes. But pardon me, Senator, that would be a comparatively small affair, because it would affect the details only of one lock, which could be comparatively quickly put in order.

Senator MORGAN. Can you state under the control of what government the protection of the Suez Canal is at the present time?

Mr. BURR. It is under the care of the English Government; but it is a neutralized waterway.

Senator MORGAN. I understand that it was neutralized through it, but I am talking about the care of the canal—the protection of it.

Mr. BURR. It is under the English Government. The English Government owns the majority of the shares, you know.

Senator MORGAN. No; it does not.

Mr. BURR. Pardon me; that is correct; it is not a majority, but a controlling interest.

Senator MORGAN. Oh, yes; it controls it.

Mr. BURR. It owns a sufficient number to control. It is not the majority; you are right.

Senator MORGAN. Well, if the English Government owned one share, that would be a majority. [Laughter.]

Mr. BURR. It would—a working majority, anyhow.

Senator MORGAN. The English Government is there, then, to maintain the protection of that canal against all invasions or troubles of every kind. It has that business thoroughly in hand?

Mr. BURR. Yes; it is practically an English Government work.

Senator MORGAN. Very good; so that there is no interruption from any neighboring government that is possible as to the control that the English Government shall exercise?

Mr. BURR. None.

Senator MORGAN. Now, when we get in full control of the Zone here, with the canal constructed through it, we shall be surrounded by neighbors on both sides who are not people of the United States, and the property will belong to the United States?

Mr. BURR. Yes.

✓ Senator MORGAN. Have you ever considered, or has any of these commissions that have been projecting the canal at Panama on either plan considered, what security would be requisite to maintain and protect that canal against attack from other governments or attack from mobs or attack from individuals, or, I will say, for instance, from an attack by a single citizen of Colombia? I would not undertake to make any inferences at all about the virtuous citizens of Panama in that connection, but I will take a citizen of Colombia. Is it not necessary, in your opinion, when the canal is completed, that the Government of the United States should be able to protect it against every possible invasion, as fully and completely as the British Government protects the Suez Canal at the present time?

Mr. BURR. Unquestionably.

Senator MORGAN. Very good. That is all I want to know.

Senator KITTREDGE. How would it be, Mr. Burr, in the event of locks?

Mr. BURR. It would be a very easy matter for a vicious enemy, or even one man, to disable one lock or two locks, twin locks, with a small amount of high explosive; and if two or three should unite to do such work, they could do a great deal of damage in a very few minutes. In fact, they could put the lock canal out of commission.

Senator KITTREDGE. In commenting upon that question Mr. Stevens, in his examination, said that the obstruction possible under the conditions that you mention would be just as easy of accomplishment in the Culebra cut by dynamiting the walls of the cut, or substantially that. Have you any comment to make upon that statement?

Mr. BURR. That is not justified by experience. You may explode a considerable amount of even high explosive on the surface of the ground—and that is what it would be—and it is true that the explosion makes a deep excavation. If that were made on the berm of the canal, for instance, unquestionably some of the material of that berm would be blown into the canal. But that would be a very small thing and might not affect navigation at all. I do not believe a mass of explosive put on the surface of the cut would have any sensible effect. It might throw some fragments over into the canal; but it

would be a very small matter, very quickly remedied, and might not have any such effect at all.

If you were to leave the Culebra cut unwatched for a week, and let a body of men go in there and make a tunnel and then take in several thousand pounds of explosive, undoubtedly you might get enough material down to partially fill the bottom of the cut; but that is an impossible procedure.

It is a matter of common experience that a very small amount of dynamite will wreck a very large amount of heavy machinery. In fact, that occurred in the city of New York only within a week, where a foundry was practically destroyed by an amount of dynamite which perhaps one man took in and set off. We all know what the effect of a torpedo was on the battle ship *Maine* in the harbor of Habana.

The placing of enormous masses of machinery and appliances and great structures like lock gates in an exposed position, where their serious damage would put the canal out of use, seems to me, and seemed to the majority, to be a most unwarranted exposure. It is true that the tidal lock in use during those stages of the tide that require it could be damaged also; but that does not destroy the canal. It does not put the canal out of commission except for the few hours that are requisite to get the débris out of its immediate position. There is no summit level to drain; there is no mass of masonry and machinery to be thrown down into another great mass of machinery and lock masonry.

Senator KITTREDGE. What is the weight of the gates?

Mr. BURR. Those gates have not been designed to the last detail, but each leaf of those gates for a lift of 30 feet will not weigh far from 450 tons, somewhere about that, and there will be some twelve or fourteen pairs of them. In other words, no ship can pass through the lock canal without requiring the movement of something like ten or twelve thousand tons of obstructions—movable obstructions, to be sure—and then moving them back again after its passage.

Senator DRYDEN. May I ask you what you mean by the "leaf" of the gate?

Mr. BURR. I mean each half of a gate. A lock is composed of two oblique parts which meet in the center.

Senator DRYDEN. Yes.

Mr. BURR. Now, each leaf is each half of the gate.

Senator DRYDEN. Yes; I understand.

Mr. BURR. So that the operation of the lock canal is one of movement of enormous masses of material which are actually obstructions. They are useful obstructions, but they are actual obstructions to the passage of traffic, and must be moved out of the way and then moved back again after the ship passes through.

Senator KITTREDGE. Last evening before adjournment (if this is a convenient point) I stated that before you closed your statement to the committee I wished information upon the question of comparative cost of maintenance and operation as well as comparative cost of construction of the two plans. I understand, of course, Mr. Burr, that that is stated in the reports of each part of the board, but I desire your comments upon the features that I have suggested.

Mr. BURR. The sea-level plan, as I have already stated in full detail, will not be in danger of being silted at any point of its length,

except possibly in the terminal approach channels, which are common to both plans. The Chagres River is so controlled, and all the streams between the two extremities are so controlled, that they can discharge no sensible amount of silt into the prism. That is a very important feature of canal maintenance. On the other hand, I showed that the Chagres and all other rivers discharge all their sediment into the lakes through which the lock-plan navigation is carried, and in such a way as inevitably to silt up the channel to a large extent; so that that feature of dredging is a very important element of maintenance in the lock plan, but it is a matter of no sensible importance in the sea-level plan.

Undoubtedly there will be some cleaning out of the channel as years pass, and there will be terminal dredging in the approach channels annually, practically continuously. But for the maintenance of the canal prism itself the amount of dredging will necessarily be very small.

Senator KITTREDGE. In which type—the sea-level plan?

Mr. BURR. In the sea-level plan.

Now, I desire to call your attention for a few minutes only to the estimate of cost of maintenance made by the minority of the Board.

Senator KITTREDGE. As to the maintenance of which type?

Mr. BURR. Both.

The cost of the maintenance of a canal is made up of a number of elements. There is this dredging of the prism wherever it is required and the cost of repairs and maintenance of masonry, machinery, and all other appurtenances and appliances which go to make up the total plant. In the sea-level plan there is the channel and the tidal lock at the Panama end, with a maximum lift of about 10½ feet only, and I have mentioned also the Gamboa dam, which is a feature of maintenance of the sea-level plan.

In the lock plan there are the four dams—one at Gatun and the three at the Pacific end—and a few other small features of similar character which amount to little. In addition to that, there is the very important item of these six great locks, with all their machinery and appliances, and the waste weir, with the controlling gates.

The only way of estimating the cost of maintenance of such works is either to deduce from past experience the per cent of first cost which represents the annual outlay in maintenance and repairs or to make an estimate of the organization of the different forces which would be required to do this work, and so arrive at the cost in that manner. Both of those procedures were considered by the first Commission, of 1899–1901, and both have been considered in the present instance. On pages 97 and 98 of the minority report are made two estimates of cost of maintenance for both plans on both these bases. On the whole, those methods of procedure are well enough for an approximate estimate of cost, but there is one item used there which is most misleading and absolutely erroneous in its results.

Senator KITTREDGE. In which—

Mr. BURR. At the top of page 97.

Senator KITTREDGE. In which estimate?

Mr. BURR. In the estimate of the cost of maintenance of the sea-level plan. I believe its application is erroneous in either case, but it is especially so for the sea-level plan. The old French Suez Canal

Company in its earlier days used seven-tenths of 1 per cent of the total cost of excavation as the cost of annual maintenance of that canal. You will remember that that is a shallow cutting across the desert. There is one place where hills occur where the depth of excavation was about 90 feet, but that is a maximum. In general, it is a shallow excavation across the desert.

Furthermore, the winds of the desert raise the sand and blow it into the prism of the canal; so that the volume of solid matter in the bottom of the channel is augmented much in that way. The excavation of the sea-level canal on the Isthmus of Panama is a very deep excavation throughout about one-half of its length. The character of the country is radically different from that on the Isthmus of Suez. In fact, the two conditions are about as absolutely and radically different as any two conditions that can be imagined, and a percentage of the cost of excavation applicable at Suez would be an utterly misleading gauge for the cost of corresponding maintenance of the Panama Canal; and yet that seven-tenths per cent is employed.

Senator KITTREDGE. Right there, if it will not interrupt you: Do I understand that that is erroneous to the extent of the amount given—a million and a half dollars?

Mr. BURR. Very nearly. There would be some small amount of excavation for maintenance in the canal prism, but it would be very small—in fact, so small that I do not know that it can be estimated.

Senator KITTREDGE. Then, as I understand you, your statement is that this item of \$1,512,000, stated in the minority report, is erroneous practically in toto?

Mr. BURR. It is erroneous. What that item should be I do not know. There should be something, two or three hundred thousand dollars or some small amount of that kind at the outside; but it is erroneous almost to its full extent. The application of the same percentage to the cost of excavation in the lock plan is more nearly correct. In fact, it may possibly be approximately correct for that plan, because all the silt from the tributary rivers is pouring into the lakes in such a way as to silt up the channels to a considerable extent; hence there will be necessarily a large annual cost for dredging. I should not suppose it would be as high as \$450,000, but it may be. At any rate, that item of \$1,512,000 in the cost of maintenance of the sea-level plan is almost entirely erroneous.

Then, again, the method used by the Isthmian Canal Commission of 1899–1901, which is shown at the top of page 98, has an erroneous application to this sea-level plan for the same reason. You will notice an item in the engineer department of \$652,932. While that would cover the item of dredging for maintenance, it would be out of all proportion as applied to the sea-level plan, for the reason that the silt is kept out of the prism of the canal. There should be a large item, or a substantial item, in that place, but what it would be it is difficult to say, except that there would be dredging at the terminal approach channels, and perhaps a little somewhere else, but one-half of that would be more than ample. Instead of \$652,000, \$300,000 would more than cover it.

With all the conditions of filling and silting which exist at the Suez Canal, and they are intense there both in the terminal approach channels and through the desert, the total amount of excavation in

the Suez Canal, averaged annually up to 1893, was only about 1,410,000 cubic yards, and it certainly would not be as much as that, or anywhere near, in this canal; but if you were to take that and apply to it the cost of 20 cents a cubic yard, which is a very full price, you would have about \$280,000 only instead of \$652,000, so that the annual cost of maintenance, instead of being \$2,360,000, as given by the minority, should be reduced by at least \$750,000, which would make that annual charge \$1,610,000.

The difference between that and the estimated cost of maintenance of \$2,400,000 required for the lock plan and estimated by the minority is practically \$800,000. That saving of \$800,000 annual expense constitutes an item of cost to be charged against the lock plan, but it has not been so charged. If we were to capitalize that at 2 per cent, which I suppose would be permissible for Government purposes, it would make an item of \$40,000,000, or if we were to capitalize it at 3 per cent it would make an item of about \$27,000,000.

The CHAIRMAN. While you are on that, Mr. Burr, the additional cost of one plan over the other, if I recollect it, is about one hundred million dollars, so there would be an expense every year of \$2,000,000 on that account to be charged against the sea-level canal?

Mr. BURR. That is true, on that basis. But the point I make here, Mr. Chairman, is that the estimated cost of the lock plan—that is what I am getting at—is not simply \$140,000,000, but is \$140,000,000 plus this capitalized amount, whatever you choose to take it—\$30,000,000, if you please, which would make \$170,000,000; and then there must be added to that the cost of the lands flooded on the Isthmus by these lakes. We shall keep in mind the figure of \$170,000,000, and now I should like to take up, for a moment, with you the subject of these submerged lands.

The minority has estimated, and correctly, that the submerged territory is about 118 square miles; but, as nearly as can be determined, about 58 square miles are owned by the United States Government; that is, are supposed to be owned by the United States Government.

Senator TALIAFERRO. You are referring now to the lock plan?

Mr. BURR. Yes, sir; I am now referring to the lock plan, and I am getting at the total cost, which should be charged to the lock plan. I am endeavoring to get at what is a reasonable estimate of the value of the lands submerged by these terminal lakes, chiefly by Gatun Lake. The total area is 118 square miles, and of that it is supposed that the United States Government owns 58 square miles. That 58 square miles is treated by the minority as if it had no value.

Those who take a first view of that territory would probably say that that estimate was not far wrong; but it is the best land in the whole Republic of Panama, outside of the city properties of Panama and Colon, because it is served by the railroad. There is much valuable land, although at first sight it does not appear to be so. There are banana plantations, there are villages upon it, and it is productive of agricultural and other values of large amounts. But that is all treated as of zero value. Of the remaining 52 square miles, 32 square miles, or 20,480 acres, is under private ownership, and 28 square miles, or 17,920 acres, belongs to the Republic of Panama or to private owners outside of the Zone.

Senator MORGAN. By private ownership, do you mean ownership under lease or under fee-simple title?

Mr. BURR. Under title; supposed to be.

Reading from the minority report: "An approximate estimate may, therefore, be based on the price per acre paid by the canal company for the whole area it acquired, and such an estimate would be 38,400 acres"—the sum of these two quantities not owned by the United States, "at \$7.70 per acre, making the total cost under \$300,000."

Senator TALIAFERRO. Let me inject a question there, please: How do these lands claimed there to be owned by the Government compare in quality to the lands under private ownership and the ownership of the Government of Panama?

Mr. BURR. They are largely of the best, because they are largely the land on which these villages along the railroad are located. It is the most valuable land of the whole. That is, there are some lands under private ownership in the villages, but I mean the larger portions of those villages, are located on the United States Government land. I think that that is a serious feature of the treatment of this question. There has been applied to this land its value of from twenty to twenty-five years ago, when it had practically no value. It is true enough that at that time it was not worth much; but it seems to me that we must treat this question under the light of present experience, if we are to meet it fairly.

Senator MORGAN. But the treaty is the other way?

Mr. BURR. In what way, Senator?

Senator MORGAN. That the land when condemned shall be taken at its value without reference to any improvements that have taken place since the date of that treaty.

Mr. BURR. Exactly.

Senator TALIAFERRO. I understand that Mr. Burr is now discussing the value of the land that this Government has acquired.

Mr. BURR. The treaty does state that the value of the land taken shall be that which held at the time of the making of the treaty. That is correct.

Now let us consider that for a moment and see what happens. Before the treaty was executed, in the latter days of the New Panama Canal Company, there was a dispute between the canal company and the pretended owners of some lands on the westerly side of the Rio Grande estuary, in the marsh, and on the side of the hills [indicating on map]; there was nobody living on it, and in fact it was worthy of the title which the minority very properly gives it, of worthless jungle. The matter was in court interminably, as those things usually are, or have been down there, but eventually the New Panama Canal Company was obliged to pay \$1 in silver per square meter for the amount that it took. In other words, at the rate of about \$2,000 gold per acre for worthless jungle, where no one lives, and which is not used for agricultural purposes or for anything else.

Immediately after the execution of the treaty the Commission, of which I was then a member, desired to purchase about 35 or 36 acres—I have forgotten the exact amount—on the slope of Ancon Hill, within the former city limits of the city of Panama. Obviously that made it suburban property; but a large portion of it—more than half was on a wooded slope of Ancon Hill, so steep that a goat could

scarcely climb it, and which would be of no value to anybody at any time; and yet it will surprise you, gentlemen, to hear that the owner of that land demanded \$300,000 gold for it. Of course, he did not get it. The Commission finally offered him \$55,000 gold, and he declined that. Condemnation proceedings were then begun, under the terms of the treaty, and he received between \$41,000 and \$42,000.

Senator MORGAN. Was he a citizen of Panama?

Mr. BURR. He was a citizen of Panama. That was at the rate of about \$1,200 an acre; and there are claimants of that marsh land, attaching to it a value of \$500 to \$1,000 an acre. There is a large amount of marsh land covered by Sosa Lake, and two or three claimants of that land appeared before the Commission when I was a member of it and in Panama. One of them said that he wanted this claim adjusted; that he could show that he had title to this land, although the United States had bought it with the railroad in good faith; it was a part of the railroad land. I do not think he had a shadow of justice in his claim, but still he made it, and I think he is making it still. In our discussions with him, he wanted a thousand dollars an acre. He finally said that he was willing to compromise at \$500 an acre.

Senator MORGAN. Would it not be cheap to get rid of such people at \$500 an acre?

Mr. BURR. I do not know but it would. I do not think that claim has ever been adjusted, but there are scores of such claims.

Senator ANKENY. Are you familiar with the hospital incident, where we had to buy land there to increase the hospital grounds?

Mr. BURR. Yes. I say that I am familiar with it. I am not familiar with the details, but I know the land, and have been on it, and looked over it with Governor Davis. I think the price paid there was something like \$1,200 or \$1,300 an acre. It was some such sum as that.

Senator ANKENY. Yes; it was.

Mr. BURR. As a matter of fact, gentlemen, if the United States Government should complete this lock plan it would be fortunate if it got out with the payment of an average price for all the land covered, of anywhere from \$300 to \$500 an acre, judging from actual experience which we have had there.

The CHAIRMAN. You mean, along the entire distance?

Mr. BURR. I mean the entire land covered or drowned by these two lakes. I am speaking from my personal experience with those incidents which I have mentioned.

The CHAIRMAN. Three hundred dollars an acre?

Mr. BURR. I think the United States would be lucky if it got out of it for \$300 an acre.

Senator MORGAN. Would not the Government still be fortunate if it got rid of those people at that price?

Mr. BURR. I do not know but that might be so, Senator, but I do not like to express myself quite that way.

Senator DRYDEN. What would that amount to, as an actual aggregate sum?

Mr. BURR. It would amount to a very large sum. I will tell you in a moment, including the whole 118 square miles, for the United States has value in that land just as much as any other party, and the whole must be included. At \$300 an acre the amount is \$18,656,000. So if you charge that up to the cost of the lock plan, instead of a total of 140,000,000, practically you have a total of \$188,656,000; and that is precisely what you have got to face if this plan of lock canal be constructed. It does not convey a proper or fair valuation of the cost of the work to put it at \$140,000,000. These are real items. They are all included in every such work in this country, and you can not escape them there.

Senator DRYDEN. And your figuring includes the capitalization of the excess of cost in operation?

Mr. BURR. Yes.

Senator DRYDEN. And that will amount to \$188,000,000, as you make it?

Mr. BURR. That would make about \$40,000,000, and added to the cost of land would make \$188,656,000. It is true, as the chairman has stated, that the interest on the difference in total cost should be considered also. I have not the slightest disposition to overlook that.

Senator DRYDEN. Would not that be 198,000,000? Forty million for capitalization, and—

Mr. BURR. Thirty millions I should have said, not forty.

Senator ANKENY. That is, the difference depending on whether you base the capitalization on 2 per cent or 3 per cent?

Mr. BURR. Yes; but call it thirty millions. For such purpose you may call it thirty millions.

Senator TALIAFERRO. What about the dam for the sea-level plan? Does not that submerge a large acreage of land?

Mr. BURR. It does; and that is a charge which would have to be considered, but there is this difference: The land under these two lakes [indicating on map], is along the railroad, and is the most valuable land in the Republic of Panama outside of the cities of Panama and Colon. The land submerged above Gamboa is of a different character. It is practically uninhabited. It is wild tropical forest land. It grows nothing. There are no bananas grown up there, and while there is the little village of Cruces which would have to be moved back to the hill, and a little place called Palo Grande, where one or two native shanties are found, and you may see the same thing at Pihiva. It is practically uninhabited, and put to no valuable purpose at all. It is clear out of the way of the canal line or the railroad line, and what it should be taken at I do not know, but the value is very small.

Senator TALIAFERRO. If the Government wanted it for the purposes of that dam, however, those people would want just as much for it, probably, as the owners of the other lands want for theirs?

Mr. BURR. Yes; if it is under private ownership. It is very difficult to find out. The Panama Government would probably claim a large part of it; but I think that probably \$100 an acre would be a corresponding estimate for that, and there would be about 30 square miles.

Senator TALIAFERRO. That land would drain off all those lakes, would it not, shown on that map?

Mr. BURR. Those lakes would not exist with the sea-level plan at all. They do not exist now.

Senator MORGAN. The cost value that they put upon the lands in those villages along the side of the railroad and in other places accessible to the railroad depends upon the fact that the railroad is there?

Mr. BURR. Yes.

Senator MORGAN. The best way to meet that is to change the railroad over, as we have got to do it, and let those prices drop.

Mr. BURR. And destroy the value?

Senator MORGAN. Yes.

The CHAIRMAN. It occurred to me that \$3 would be nearer the value of that land than \$300.

Mr. BURR. I do not wonder at it, sir.

The CHAIRMAN. I think if this committee would visit that country they would think that \$3 an acre would be nearer the value of the land than \$300.

Mr. BURR. That is a fact; but still, it has much more value than appears. There is a distinct value in that land. It is capable of producing a great deal. In fact that whole country, wherever it is cleared and worked, grows everything of a tropical character luxuriantly.

The CHAIRMAN. I think the only product I noticed down there was darkies. That seemed to be the main product. [Laughter.]

Mr. BURR. They are most in evidence. [Laughter.]

Senator KITTREDGE. Have you any suggestion regarding the health conditions if the lock plan is adopted and these swamps created?

Mr. BURR. I have a suggestion. It is not a practical point of so much value or so much importance as that which I have just noted, and yet it seems to me that it is a very important consideration. In fact, I think it is a very important consideration to destroy this land. I believe that the whole Canal Zone will be covered in the comparatively near future with a population much better than that which now exists, and a productive one.

Those people will learn industry, or at least those who follow them will; perhaps the adults now never will. But it seems to me a very serious matter to wipe out of existence all that valuable territory which could be made productive and contribute to the wealth of the Zone.

There is, however, one serious sanitary feature which I believe should not be overlooked, although it can not be stated in dollars and cents. The flooding of the land by those two lakes will cover up a great many mosquito-breeding marshes, as they now exist. That is true. But they will make a great many more. While this map is not absolutely accurate in all its details, the general character of this serrated margin of the lake is correct. There is much shallow water, and all around these marshes we have shallow water which will support dense aquatic vegetation.

We have observed that already in our little Rio Grande reservoir, from which the city of Panama draws its water. Aquatic vegetation grows there luxuriantly at a depth of 6 or 8 feet below the surface, at least, and that makes a margin where the malarial mosquito breeds, not by the millions, but by the millions of billions. There would

therefore be created a most favorable breeding spot of enormous area for these malaria-bearing mosquitoes.

Senator MORGAN. With no chance to screen them off? [Laughter.]

Mr. BURR. With no chance to screen them off. Obviously it is not important in such out-of-the-way places as some of the portions of this lake, but all through the main part it would be a very serious matter. As a matter of fact, malaria has been a much more serious sanitary feature of the Isthmus than yellow fever, although yellow fever has attracted all the attention. The yellow fever can be controlled. The yellow-fever-bearing mosquito is a domestic insect and breeds in clear water about houses, and they are practically exterminated.

I believe that yellow fever has ceased to be an element in the conditions of life on the Isthmus, but malaria among the natives will never be eliminated. It will be reduced to some extent, but anything which increases to an infinite extent, as the submerging of land by these lakes does, the capacity to breed those disease-carrying insects, it seems to me is a most serious feature, and it is one whose serious character will be appreciated more and more as the years go on.

Colonel Gorgas told me in conversation in response to my inquiry that such marshes where aquatic vegetation grows would be productive of just such conditions as those which I have described. In fact, one need not go to even a mosquito expert to know that, because it is a matter of common knowledge.

The United States Government has literally been spending millions of dollars to eradicate just such mosquito-breeding places as this since the Commission took possession, and it is doing it at present. It will continue to do it. These lake conditions are calculated to intensify the results which the Government has been spending millions of dollars to get rid of. It strikes me as being a very serious feature, although it can not be expressed in money value.

Senator KITTREDGE. The chairman earlier this morning, Mr. Burr, asked you at some convenient time to comment upon the testimony of Mr. Stevens. Is it convenient for you to take that up now?

Senator MORGAN. The question as propounded, it seems to me, is a little too broad—to comment upon the testimony of Mr. Stevens. It would be appropriate, I think, to ask the witness to state any facts in the testimony of Mr. Stevens that he does not think are substantially correct or properly stated.

The CHAIRMAN. That was the intention.

Senator KITTREDGE. It was not intended on my part to be in the form of a question, but simply to call the matter to the mind of the witness.

The CHAIRMAN. I think it was understood yesterday that that would be a matter to be taken up by Mr. Burr.

Senator TALIAFERRO. Is there any point in Mr. Stevens's testimony that you wish to comment on?

Mr. BURR. There are some points, and it will take but a few minutes to do it. But I should like to mention one or two matters which have occurred to me which I have not mentioned before, and which I think have a real and material bearing upon this matter.

The CHAIRMAN. Just proceed with your statement, then.

Mr. BURR. It will take but a very few minutes to do it.

Much has been said in connection with the lock plan about the ease with which the prism or the dimensions of the canal may be increased throughout its length. Now, that is true, but the point which is missed entirely in that statement is this: That while it is easy and economical to increase the dimensions of the canal prism between Gatun and Pedro Miguel, that will not increase by one ton the traffic capacity of the canal. That is the point that I want to bring out. This ease of enlargement has been mentioned and emphasized as if it were going to give increased capacity to the canal. That is not the case.

The capacity of the canal is determined by the capacity of the locks; so that you may increase the dimensions of the prism to any extent between Gatun and Pedro Miguel, but the capacity of the canal will not be increased an atom until you give additional capacity to the locks, and that means their reconstruction. It is planned to get 5 feet greater depth in the locks, 40 feet now being allowed for. But increasing the depth of water in the locks will not increase the capacity of the canal to any sensible extent, because it leaves the usable length and the usable width unchanged.

The next point relates to the transformability of this plan. When the President gave his instructions to the Board he emphasized that feature very much, and there have been expressions in the public press which are based upon the supposition that this particular plan of lock canal lends itself admirably to transformability. As a matter of fact, it is that plan of all other lock plans which both the majority and the minority agreed was so little adapted to transformability that it was believed in the Board unanimously that if this lock plan were once constructed, there never would be a sea-level canal across the Isthmus—that is, within any reasonable period in the future. In other words, that if this plan were adopted that settled the matter of transformability, and that a sea-level canal never would be attained.

Senator KITTREDGE. You now speak of the lock canal?

Mr. BURR. This lock plan; yes. In other words, it was not considered feasible or practicable within the reasonable meaning of those terms to transform this plan to a sea-level canal. That is a matter which I want to emphasize with great earnestness, because there have been some very erroneous impressions abroad in regard to it. Neither the majority nor the minority considered it adapted to transformability, and both portions of the Board assumed practically that if this plan were adopted the sea-level plan would not be attained.

Senator DRYDEN. If the lock type of canal were adopted, and it should be found that the traffic required an enlargement of the canal, could not the locks also be enlarged to accommodate the increased traffic?

Mr. BURR. They could be. It would be a very costly and inconvenient work to accomplish, but it can be done, and it undoubtedly would be done.

Senator DRYDEN. Then that would provide facilities for the increased traffic, if the locks were enlarged?

Mr. BURR. Yes. It is possible to transform any lock plan to a sea-level canal if you take the time and the money; but the real practicability of such a change, of course, is a different question.

Senator TALIAFERRO. If this lock plan is adopted, and the lock canal is built, could it, in your judgment, be transformed into a sea-level

canal at anything like the total present estimated cost for the sea-level canal?

Mr. BURR. Nothing like it. I am very glad that you have asked me that question. I can very quickly put that in dollars and cents. The Board—and when I say the Board I mean the concurrent action of the majority and minority in this case—estimated the cost of transformation of a lock plan practically identical with this to a sea-level canal, and that cost, at the unit prices adopted by the Board, is \$208,985,000, as found on page 39 of the report. Now, add to that even the minority's estimate, its own cost, without adding the forty-eight millions of dollars, which ought to be added for the items that I have just stated, taking \$140,000,000 only as the partial cost, and we shall have the cost of transformed canal on that basis as \$348,985,000, and that is only a partial cost, because the expense which has been incurred between the application of the lock plan and its transformation, the additional cost which would be paid in maintenance, lands and other damages, are all omitted. But take it even on that basis, in round numbers, and it makes the attainment of a sea-level canal cost \$350,000,000.

Senator KITTREDGE. What about the interruption of traffic?

Senator MORGAN. It would cost \$350,000,000 to transform it from a lock canal to a sea-level canal?

Mr. BURR. It would cost much over \$350,000,000 for a sea-level canal by first constructing this lock plan and then transforming it.

Senator MORGAN. That is what I meant.

Mr. BURR. That is right.

Senator DRYDEN. Would it, or not, be true that if a lock canal was transformed into a sea-level canal a very large expenditure of money for the purchase of lands and for other purposes would then have proved a wastage, and would be thrown away?

Mr. BURR. It would; in fact the cost of these great dams and locks would all be wasted.

Senator DRYDEN. Running into many millions of dollars, according to your statement, I assume?

Mr. BURR. Yes, sir.

Senator MORGAN. Then the project of transformation, if I understand it, was rejected by the entire board?

Mr. BURR. The project of the transformation of this plan was rejected by the entire board, but not the project of transformation by some other plan.

Senator MORGAN. What other plan?

Mr. BURR. It was regarded as perfectly feasible, and not incurring great difficulties, to build a lock canal by bringing the sea-level section up to perhaps Obispo, constructing the Gamboa dam as in the sea-level plan, making the locks at Obispo to raise the level up to 60 or 85 feet, or whatever might be settled upon, and then building other locks at Pedro Miguel, and either at Miraflores or at Sosa Hill. In that case, if such a lock canal were reduced to a sea-level canal, the wastage or superfluous works would be a minimum; that is, would be simply the locks at Obispo, at Pedro Miguel, and at either Miraflores or at Sosa Hill.

Senator TALIAFERRO. And the cut through Culebra?

Mr. BURR. There would be no wastage on that. That would be simply enlarged. The only wastage would be what I have stated.

That is the lock plan which is best adapted to transformation, ultimately, to a sea-level canal.

Senator MORGAN. That means a lock plan extending from Gamboa across to Miraflores?

Mr. BURR. Yes, sir.

Senator MORGAN. And the balance of it sea level?

Mr. BURR. Yes, sir; the balance of it sea level.

Senator KITTREDGE. Did you estimate the cost of transformation of that sort of a lock canal?

Mr. BURR. That was not estimated. It could be estimated on the same unit prices, but it was not. It would be far less than this.

Senator MORGAN. If you had a sea-level canal from Gamboa to the Bay of Limon and a sea-level canal from Miraflores to the Bay of Panama, by what means would you lift the vessels from that sea-level canal up to the lock canal that would span the distance between Gamboa and Miraflores?

Mr. BURR. Why, lift them in locks in the usual way.

Senator MORGAN. Is that practicable?

Mr. BURR. It is simply using the lock feature of a lock plan. That is all.

Senator MORGAN. And using it at Gamboa?

Mr. BURR. No; not at Gamboa, but at Obispo, or some point near Obispo.

Senator MORGAN. I meant in that vicinity?

Mr. BURR. Yes, sir.

Senator MORGAN. Using it there where the rising ground commences?

Mr. BURR. Yes, sir.

Senator MORGAN. And locking down where the rising ground falls off into a level?

Mr. BURR. Yes, sir.

Senator MORGAN. So that in that instance you would have a lock canal between those points that you speak of as high ground and a sea-level canal from those points, say Miraflores and Gamboa, out to the sea on either side?

Mr. BURR. Yes, sir.

Senator MORGAN. Would the control of the Chagres River be as convenient and certain and definite and satisfactory with locks located at Gamboa or in that vicinity as it would be with locks located anywhere else?

Mr. BURR. It would be more so, Senator, because a dam at Gamboa would keep any silt from the upper Chagres from entering the canal. In my judgment, that is the best plan of lock canal which has yet been suggested.

Senator MORGAN. To confine the lock system to the high ground, commencing, say, at Gamboa and ending at Miraflores?

Mr. BURR. Yes, sir.

Senator MORGAN. The balance of it to be sea level?

Mr. BURR. Yes, sir.

Senator MORGAN. In that case the transformation would take place without wastage, if I understand you?

Mr. BURR. With the minimum amount of wastage.

Senator MORGAN. That is what I meant.

Mr. BURR. Yes, sir. There would be the wastage only of the locks; that is all.

Senator MORGAN. In that case you would still retain the dam and whatever was necessary probably besides the locks at Gamboa, for instance?

Mr. BURR. You would.

Senator MORGAN. For the purpose of controlling the Chagres floods?

Mr. BURR. Yes, sir. Then, you see, when the canal was reduced to a sea-level canal, the Gamboa Dam and all its controlling works would be available for the sea level.

Senator MORGAN. For the control of the Chagres?

Mr. BURR. Yes, sir.

Senator MORGAN. As to the sea-level canal?

Mr. BURR. After the sea-level canal is reached.

Senator MORGAN. That would not be wasted?

Mr. BURR. No, sir; that would all be used.

Senator MORGAN. But the locks from Miraflores to Gamboa would be wasted?

Mr. BURR. They would be wasted. The locks would all be wasted.

Senator MORGAN. That is the sum of the situation?

Mr. BURR. Yes, sir.

Senator TALIAFERRO. That would get away from the mosquito theory, too?

Mr. BURR. Oh, yes; it would obviate that.

Senator MORGAN. I have been trying to think out that plan in my own little way, but it got too big for me when I got to Gamboa. I could not handle it.

Mr. BURR. In commenting on the facts stated in the evidence of Mr. Stevens I shall of course not duplicate or repeat what I have already said on the same points. This matter of the land valuation which I have recently spoken of is touched upon by him on page 897. He states:

"I figured that putting the value of the land as high as I possibly could, stretching my conscience to that extent—mind you, if I were buying there I would not pay any such prices—it would be necessary to acquire not to exceed \$300,000 worth of privately owned tracts."

I differ radically from that. It would be many millions, for the reasons that I have just given.

Senator DRYDEN. There is a difference of over \$18,000,000 between you on that proposition, as I understand it?

Mr. BURR. There is some discrepancy, Senator.

Senator MORGAN. In the case of a lock canal between Gamboa and Miraflores, which would pass through the Culebra cut, how could the transformation be made, say in the greater depths of the cut there, while the canal was in operation, without widening that cut to perhaps double the width?

Mr. BURR. Either in transforming a lock canal to a sea-level canal, or widening a sea-level canal, it would only be necessary to take off a uniformly thick layer of material.

Senator MORGAN. On one side?

Mr. BURR. On one side or divided between the two.

Senator MORGAN. Up to the top?

Mr. BURR. Up to the top.

Senator MORGAN. Very good.

Mr. BURR. From the top down to the bottom of the canal.

Senator MORGAN. But in transforming a lock canal into a sea-level canal on the plan proposed it would be necessary to take off this space. Now, could that be done with the canal still in use?

Mr. BURR. Oh yes, sir; there might be a little inconvenience to some ships at times, but it would not be serious.

Senator MORGAN. You could maintain the lock system through that whole affair until, by sections, you could replace it with a sea-level canal?

Mr. BURR. Yes, sir; provided the locks are designed for that purpose when first built.

Senator MORGAN. Well, of course.

Mr. BURR. Yes. That is entirely feasible.

Senator MORGAN. It is entirely feasible?

Mr. BURR. Entirely so.

Senator KITTREDGE. What would be the increased cost, if any?

Mr. BURR. I have not the estimate made for that particular transformation, but the estimated cost of transformation of the actual plan would be as I have given it. What it would be from the lock plan which I have suggested to a sea-level plan I can not state. To make a rough guess, it would be less than half that of the other plan.

Senator KITTREDGE. How much more would it cost to construct a canal with locks such as you have just now suggested and then transform it to a sea-level canal than it would to construct a sea-level canal in accordance with your proposition?

Mr. BURR. Well, the principal item of waste would be the six locks. I suppose that that item would be represented by about thirty-five to forty millions of dollars. Then, the added cost of excavation to be made under those circumstances is something that would have to be determined by very careful consideration of all the circumstances; but I feel confident that my guess of less than half of the cost of transformation by this process would be true.

Senator MORGAN. That is chiefly on account of the facility of carrying off the spoil.

Mr. BURR. Yes; and then the waste of these great dams and locks in the present lock plan.

Senator MORGAN. If you had a canal through what we call the Culebra heights in operation, and you wished to widen or transform that canal by cutting down the bank on either side, or on both sides, it seems to me that there must be a very important advantage in having water transportation for the spoil out to sea on the canal?

Mr. BURR. There is. There is no question about that. And it is quite possible, too, that our means for excavating rock under water will be so improved as to reduce the cost of that part of the process of transformation. We can not say how much, but that is a reasonable expectation.

My attention is first attracted to a statement by Mr. Stevens on page 918. On that page I observe that Mr. Stevens states that "a very large ship could never be assured of getting through a sea-level canal of the dimensions reported without grounding, unless she ran at

such speeds as would practically destroy the usefulness of the canal, for this reason, that out of the 49 miles there is over 29 miles that is only 200 feet wide, and you can see from the map that it is more or less tortuous in direction."

I can only say that the experience in ship canals all over the world flatly controverts that statement; that is, it is contrary to experience in such ship canals as the Suez, Manchester, Kiel, and other ship canals of Europe, all of which have materially less prism dimensions than the sea-level plan proposed.

Senator DRYDEN. Is the curvature in these canals as sharp as in the proposed sea-level canal?

Mr. BURR. In some of them it is sharper, Senator.

Mr. Stevens further says that "this situation would be accentuated by the immense number of small streams carrying flood water directly into the canal at the depths that they would, from 30 to 150 or 160 feet. They are constantly carrying in detritus that would make shallow bars that would very soon render the navigation of such a canal impracticable for large ships, and sooner or later for all ships, unless there were a fleet of dredges kept constantly working from one end to the other to keep it open."

I think that probably Mr. Stevens had not at that time an opportunity to examine the sea-level plan, because it is one of the marked features of that plan, as I have emphasized over and over again, that no detritus from any stream is carried into the canal—absolutely none.

Senator DRYDEN. I would like to ask one more question on this point of curvature before we leave this finally. Are the vessels which pass through these other canals—the European canals and others which you have referred to—as long and as large as the vessels that will be likely to pass through this canal in the Isthmus of Panama?

Mr. BURR. The largest vessels that I know of that are passed through those canals are a little less than 600 feet, as I stated earlier in the session to-day. They have repeatedly passed through the Suez Canal, which has a much smaller prism than the recommended sea-level prism in this plan.

Senator TALIAFERRO. And practically as much curvature?

Mr. BURR. Practically as much curvature.

I have noticed on page 925 and at some other points Mr. Stevens's statement to this effect: "The consulting board, I understand, was created to furnish information to the Commission and to Congress. I have, however, checked independently of the board and independently of anyone an exactly similar proposition"—that is, as to the cost of the lock plan. And at some other points which I can not readily find, although it is not important, the same statement is made that the matter of determining the plan for this canal was taken out of his hands and put into the hands of the consulting board. That specific statement is made, although I can not turn to it just at this moment.

The CHAIRMAN. That is what the Consulting Board was for, was it not, Mr. Burr?

Mr. BURR. I should like to say a word or two, and that is all, in behalf of the Board on that point. In the Executive order of the President, dated June 24, 1905, this language is used: "It is hereby ordered that a Board of Consulting Engineers, consisting of"—giving

a list of the names of the members—"shall convene in the city of Washington, at the rooms of the Isthmian Canal Commission, on the 1st day of September, 1905, for the purpose of considering the various plans proposed to and by the Isthmian Canal Commission for the construction of a canal across the Isthmus of Panama between Cristobal and La Boca."

I wish to call the attention of the committee to the fact that the functions of this Board were consultative and not of a creative character. It was instructed by the President "to consider the various plans proposed to and by the Isthmian Canal Commission," and for no other purpose.

There were transmitted to the Board the plans of the Comité Technique, the plan of the former Isthmian Canal Commission, plans by Mr. Bunau-Varilla, Mr. Bates, and suggestions by one or two others, but no plan whatever by the Isthmian Canal Commission itself, although it was stated by the President that such plans would be submitted.

I believe that I am not violating the confidences or the privacy of the Board when I say that it was a matter of some embarrassment to many members of the Board to find itself in such a position that it was obliged to act in a creative capacity by the failure of the Commission to submit the plans which the Executive order said would be submitted, and that was the reason why we were obliged to create plans as well as consider some plans that were put before us. That is a chapter in the history of the Board's work which ought to be appreciated.

So that I must disagree with Mr. Stevens when he says that the function of creating plans was taken from his hands and put into the hands of the Board. I have nothing to say, of course, about his own functions. I merely mean to say that the Consulting Board was not intentionally usurping his functions.

Senator TALIAFERRO. Suppose the Canal Commission had submitted a plan, practically the plan adopted, for example, by the minority of your Board, would it have affected your Board in its conclusions in any way?

Mr. BURR. I do not think it would have affected the conclusions as to the type of canal. I think they would have remained unchanged. But it would have affected very materially much of our duties, and would have enabled the Consulting Board to have closed its work much sooner.

On page 930 Mr. Stevens questions the accuracy or the reliability of the Board's estimate of cost of certain diversion channels, including the partially constructed Gatun diversion, running from Gatun over into the Bay of Manzanillo, behind Colon, and certain dams across the Gigante and the Gigantito, and one or two other streams on the western side of the canal, for the purpose of backing them up and causing them to flow over the divide away from the canal into other streams which lead to the ocean, an item amounting to three and a half millions of dollars; and that has also been questioned by the Commission.

I simply wish to say that those watersheds were all accurately surveyed by either the old French company or the new French company, and their contour maps are strictly accurate for the purposes of such subsidiary works as these involved. That estimate of the majority

was questioned by the minority in the Board's session, and in consequence of that a reexamination of all those estimates was carefully made, and it was found that the allowance, \$3,500,000, to which the usual 20 per cent would be added, making \$4,200,000, was ample to cover all those items.

Senator KITTREDGE. Did the minority agree to that proposition?

Mr. BURR. It was a matter which did not come up for action in the Board, so that there was no opportunity for formal agreement, but I suppose that they were satisfied at the time. I can not state whether they were or not. Although it is a small item, it was most carefully reexamined and checked, and I am confident that it is ample to cover those items.

On page 931 Mr. Stevens questions—I will not say questions, but expresses a little doubt as to the stability of the Gamboa Dam across the Chagres. I can only say that the undoubted and indefinite stability of that dam is founded upon precisely the same elements as the stability of any similar engineering work.

If it is designed either as a masonry dam on bed rock, or if it is a great earth dam with the masonry core carried down to bed rock, all as recommended by the majority of the Board, it will be as firm and stable as one of the mountains adjoining it, and an earthquake would not affect it. It will be, when completed, with the earth fill on either side—and that really should be used whichever type is adopted—practically a mountain across the valley. There are much higher masonry dams, one recently completed across the Croton River near New York for the water supply of that city. There is not the slightest question of its stability, if it is properly designed and constructed, which, of course, would be a matter in the hands of the constructing engineer.

On pages 935, 936, and 937, Mr. Stevens again enlarges upon the difficulties of getting large ships through the sea-level canal. I can only state what I stated before, that the world experience with ship canals is directly at variance with his suggested difficulties, even where those canals have a less prism or less dimensions than that of the proposed sea-level canal. There would be no difficulty whatever in getting a thousand-foot ship through the sea-level canal.

Senator ANKENY. No difficulties of whatever kind due to curvature, depth of water, or anything?

Mr. BURR. There would be no difficulty whatever.

Senator ANKENY. Of any kind?

Mr. BURR. Of any kind.

Senator ANKENY. I thought you were confining yourself to the question of curvature, or depth, or something of that kind.

Mr. BURR. I mean with the recommended plan of the sea-level canal, with the curvatures and depths and dimensions there adopted.

Senator ANKENY. There would be no difficulty with the greatest ships afloat?

Mr. BURR. With the greatest ships afloat. Of course, the largest ships afloat would go through with less speed than the smaller ones.

Senator ANKENY. I understand; but there would be no physical difficulty whatever?

Mr. BURR. No physical difficulty whatever. That objection is very much like one which was made some time before the New York subway

was opened, when it was stated that the curves were so sharp that it would be impossible to get a train around them. A good many trains have since passed without the slightest trouble. It will be the same way with this canal.

On page 940 Mr. Stevens mentions the fact of doing damage with high explosives on the banks of the canal; but as I have already touched upon that, I will not repeat what I have said.

On page 942 Mr. Stevens says in one place: "There are one or two discrepancies, however, in the majority report which I can not quite reconcile which must be taken into consideration." And then a little further on:

"Now, frankly, I do not believe that the sea-level estimate is correct, for several reasons. In the first place, while I am chief engineer of the Commission, I never yet have satisfied my own mind or become satisfied as to what it is going to cost, even approximately, to take out the lower 40 feet of that canal through Culebra Cut."

Then, still further on:

"The Board reported that the cost of taking out the material from plus 10, which is 10 feet above the sea level, down to minus 40, which is 50 feet (40 feet of which, as this profile shows and as we all know, is rock), \$1.25 a yard. Well, I do not know anywhere in the world where rock has been ever taken out under just those conditions—in other words, under as hard conditions as these would be. I have not studied up any plan yet whereby, either as engineer or contractor, I would start to take it out. Of course it is possible that that estimate may be correct."

I think that the chief engineer scarcely gave that matter sufficient consideration. Of course if he says deliberately that he is unable to determine any manner of taking that rock out, I should have to accept his statement; but I believe that he is too good an engineer really to mean that. Rock has been taken out in this country and in other countries the world over for, I was going to say, centuries; perhaps that is a little extreme, but in all the past history of modern engineering works, in precisely those conditions.

There is at the present time in progress a contract which I have already mentioned in St. Marys River which was let in 1904, I think, to MacArthur Brothers, of Chicago, for taking out about 2,000,000 cubic yards of rock under water in the bottom of that part of the St. Marys River channel which is called the Upper and Middle Neebish. The water of the river was flowing over it, and yet they agreed to take that out for \$1.36 a yard and are having a very profitable contract.

They did that, however, by putting a dam across the river at either end of the stretch which was to be excavated and then unwatering and excavating it in the dry.

I was engaged myself, commencing three or four years ago, in connection with a contractor in New York, acting as his engineer, in taking out a large amount of rock, mud and sand under water, on a line of the subway where it crosses under the Harlem River at a depth of 55 feet below the surface. That space was also unwatered, and the rock was taken out without the slightest difficulty.

In regard to the Culebra Cut, as I have said before—and will say it again with all earnestness—if one can clear the lions out of the way,

which exist in the imagination of so many people, that work has no more real difficulties than work that is being constantly done on a large scale by contractors in this country every year. The Culebra Cut is a cut through a great hill. It has hard rock at the bottom in large quantities—perhaps all hard rock. It has softer rock above, and clay on top. It is simply a matter of undertaking that large piece of work intelligently and carrying it through.

The excavation above plus ten was put at 80 cents a cubic yard by the Board. I believe that price is too high, for the reasons I have already stated, but I concur in it and accept it. We all accepted it, because we believed it was better to overestimate the cost of this work than to underestimate it.

The rock below water, to be taken out under water, was put at \$2.50 per cubic yard, which is far more than required anywhere on the Isthmus or here. It is being taken out in Europe by Mr. Hunter, who was a member of this Board, at about 70 cents per cubic yard in his work, and it can be taken out on the Isthmus of Panama for probably one dollar to one dollar and a half a cubic yard—actual cost, I mean.

The Board named \$1.25 per cubic yard for the excavation of the rock between plus ten and the bottom of the canal for the reasons which I stated yesterday. The rock is harder at that depth, the space is more cramped and limited for the use of tools and appliances, and it has to be lifted somewhat higher, but it is a perfectly plain, straight piece of excavation of rock in the dry. There will not be a yard of that rock taken out under water. In fact the sea water can not get into the bottom of that Culebra Cut until it is permitted to come in. The bulkhead or dam at each end will keep all water out—sea water or any surface water. What little water comes in from springs or which flows down from the rainfall into the pit will be pumped out just as it would be pumped out here.

There is not a single process of that operation from beginning to end which is not in standard and daily execution by contractors and engineers in this country—I was going to say every day in the year, and I believe that that is not very far out, excepting Sundays, and sometimes not excepting Sundays even. But there seems to have been in some way or other in the minds of so many people an awe-inspiring apprehension that somehow or in some way, or from some source, that work is surrounded with difficulties indescribably and obscurely dreadful, and Mr. Stevens seems to be affected a little that way. As a matter of fact, that price of \$1.25 a yard was agreed to by the entire Board.

I have forgotten whether the vote was unanimous or not, but it was a board price, and not a majority price or a minority price. It is ample to cover all that work. Furthermore, there is not an item of estimated cost of excavation or masonry either in the majority report or the minority report which was not gone over with the most scrupulous care; and I can only account for Mr. Stevens's statements in regard to it as being made hurriedly, without the time to examine the data carefully. I believe those must have been the circumstances under which he gave his testimony. I think that if he had had the time to look over these matters carefully, he would not have made the statements which are found here.

On page 943 he mentions the matter of maintenance and operation, which I have already covered in detail, and which, therefore, I will not repeat. He, in my judgment, makes the same error that the minority commits in dealing with that feature of the question.

On page 945 he speaks of the effect on the canal if the Gamboa dam should be carried out. You might just as well spend time discussing the effect which would result if an earthquake should shake together the two sides of the Culebra cut, after the canal is completed on either plan. The stability of a simple work of that sort is assured beyond all question at the present time.

On pages 956 and 957 Mr. Stevens makes reference to what was found in the borings shown on that blueprint plan before you, and there again I think that he would have modified his statement if he had had time to consider it. I feel sure that some of the statements made here are due to inadvertence, because they are directly at variance with what was actually found in those borings. He states at one point, for instance, that "the result showed that something like 200 feet overlying the rock—the so-called 'indurated clay'—there was a blanket of clay, with a small mixture of very fine sand, and that no permeable material—that is, material that would carry water—was found for a depth of about 200 feet."

I pointed out yesterday, and it can be seen from that blueprint plan, that from depths of 32 feet down to over 200 feet the water-bearing material, and of course permeable material, consisting of sand and gravel and sometimes a mixture of sand and clay, were found at various depths. In other words, permeable water-bearing material was practically found all the way down from about 32 feet below the sea level to nearly 250 feet. I feel confident that these statements were due to inadvertence on the part of Mr. Stevens, but still I think that I ought to call attention to them.

Mr. Stevens, on pages 959 and 960 and at some other points, speaks of the greatly increased permeability of material at the Bohio site over that at Gatun, and that there was no permeable material at Gatun. Now, that is partially in accordance with the facts—that there is more permeable material at Bohio than at Gatun; but at Gatun there is a large amount of permeable material also, as is shown by that blueprint plan which you have before you.

One point made by Mr. Stevens, on page 960, is so admirable that I do not wish to lose the opportunity of concurring with him. In answering a question as to the construction of a dam at Bohio, he says: "I should certainly want to cut off some of that flow of water that might possibly occur through the subaqueous foundation." And he mentions in other places—one or two other places—that the under-water seepage should be cut off. I think that he is absolutely right in that, and I am very glad to register my full concurrence with him; but, unfortunately, the proposed Gatun dam for the lock plan is based upon a directly opposite view of that question—that it is not necessary to cut off the underflow.

On page 961 Mr. Stevens states that the deepest boring was 204 feet; but we have already observed that it was 258 feet. I presume that that was also an inadvertence.

In the vicinity of page 964 he also speaks of the foundation of the

dams at the Panama end to the canal, with reference to which I have already expressed my judgment so fully that nothing further will be said about that.

On page 977 he expresses himself in reference to the time of passage of a ship through these two types of canals. He says: "I think the passage through a lock canal will be safer." And he also states, in some place that I can not directly turn to, that it is also quicker.

In answer to a question he expressed his preference for a lock canal, even if a sea-level canal could be built at the same cost and in the same time. He said even then he would prefer a lock canal. Here it is. He says, in answering a question: "Because I think that the passage of ships would be quicker. I think the cost of operation would be no more—if more, very little—in case of a lock canal. I think the cost of maintenance of a lock canal would be very much less. I think the passage through a lock canal will be safer. I think, in case future developments should require enlargement, the lock canal can be made of much larger capacity very much more quickly and cheaply than the sea-level canal."

In estimating the time of passage for a ship, he leaves out of account entirely, as the minority does also, the delays that would occur at the terminals in case a number of ships should be there at the same time; and he also omits consideration of all contingencies and exigencies which are likely to occur in connection with the operation of machinery and appliances to which I have already made such full reference.

How anyone can consider the passage of a ship through these locks, lifting them up to great heights and down again, as being safer than in straight sailing through a sea-level canal, is beyond my comprehension. I confess that I am not prepared to enter into any detailed argument on that question.

Senator TALIAFERRO. Would not that include the question of speed also—the time as well as the safety?

Mr. BURR. The time of passage involves the question of speed. It is true that over a short portion of the lake navigation there would be stretches where a ship could steam at a higher rate of speed than on the sea-level canal proposed. But even the minority does not advocate an increased speed of more than about 2 miles per hour, as I understand their position, and that is far more than made up by the delay at the locks. In fact, as I have already stated in the earlier part of this session, there is not any way in which a recognition of the actual circumstances of navigation of a ship canal can make the passage, month in and month out—and that is what you have to count on in the long run—by ships in a lock canal much less than double the time it would take to go through a sea-level canal, taking into account the delays from all sources and the repairs.

Senator TALIAFERRO. Taking into account the ideal conditions, is it not your judgment that a ship would go through a sea-level canal in much less time than through a lock canal with five or six locks?

Mr. BURR. I do think so; I think so without question, unqualifiedly.

Senator DRYDEN. Is it not claimed that the length to which the vessels can go unobstructed on this lake is about 19 miles of the proposed lock canal?

Mr. BURR. I have forgotten as to that, Senator Dryden; but there

is not that length of line which I believe would be considered safe enough for that kind of navigation. You were not present when I spoke of the dangers of submerged channels.

Senator DRYDEN. No.

Mr. BURR. A very long stretch of which is found in this lake; but there, in that feature, is found the restraining influence as to speed. The passage through submerged banks is one which is always involved in some risk, and sometimes very serious risk. Consequently a submerged channel must be far wider, perhaps twice as wide or more, to give the same safety to navigation as a channel between banks which are visible, and there is where much of the advantage of lake navigation will be lost.

I have but one thing more to state, and that is a very short and small one:

It has been stated, and is stated in the minority report, that the computed seepage under the Gatun dam can never exceed about 10 cubic feet per second (I think that is the value, but I shall correct it if it is not; I think that is correct, however), and it is said that that is too small a matter to be the cause of any apprehension.

I have been somewhat familiar with the computation of the flow of water through sand for filtration and similar purposes for a considerable period of years. The whole subject has been reduced to exact analysis within the past twelve or fourteen years only; and those computations are based upon the ideal conditions of regulated and rigidly determined sand in a laboratory. There is a uniform, perfectly uniform, texture of the sand, so to speak, in those small laboratory experiments, the results of which are the basis for this computation.

No such conditions exist in a great geological profile as those which are assumed in these small laboratory experiments. It is a purely theoretical computation, originally made by the late George S. Morison in connection with the Bohio dam, and the results of such purely theoretical computations upon assumed conditions radically different from those found at the actual site are not worthy of very serious consideration. They are certainly not of sufficient reliability and are not sufficiently well founded to justify the grave hazards which are involved in that kind of construction. They are applicable, and ordinarily made applicable only, to such artificial constructions as filter beds used in connection with public water supplies, where the whole plant is put in place in the most careful manner so as to secure the conditions which belong to the computations. Then the results of those computations are correct. But to apply them to a geological profile like that shown on that blueprint, with wide and violent changes of texture of material in the space of a few feet, is to use them in such a way as to vitiate the value of the results.

Gentlemen, that is all that I have to say, unless there are more questions to answer. After the most careful study of this question, and with a perfectly open mind, during the past six years, I am convinced that the sea-level canal will most fully meet the requirements of this great waterway, and that it is the only type of construction which this Government should undertake. I believe that even if a lock plan should now be adopted, and if work should be begun on it, the completion of the work would find it a sea-level canal.

The CHAIRMAN. Gentlemen, do any of you desire to ask Mr. Burr any further questions? If not, Mr. Burr, we certainly appreciate your presence here, and thank you very much for coming.

(The committee thereupon adjourned until to-morrow, Saturday, March 10, 1906, at 10.30 o'clock a. m.)

Supplementary written statement of William H. Burr, esq.

280 BROADWAY, NEW YORK, March 29, 1906.

DEAR SIR: On reading over my testimony, given before your committee, I find a few points on which I should like the privilege of extending the observations which I have already made, if such a privilege is consistent with the procedures of your committee.

In my testimony concerning the proposed Gamboa dam, whether it be made of all concrete masonry or of a heavy concrete masonry core in a great earth embankment, the height of such masonry from bed rock 50 feet below the bed of the river to the highest water surface of the lake would be 170 feet. In any event the construction of this dam involves no procedure other than that which has commonly been used heretofore.

Nor is this total height of masonry nearly as great as is found in some existing masonry dams. One instance only need be cited in this connection. The masonry dam recently completed at the new Croton reservoir of the water-supply system of the city of New York has a total maximum height from the bed rock on which it stands to the highest water surface of 241 feet. This height is 71 feet in excess of that proposed at Gamboa.

In discussing the relative costs of the sea-level and lock type of canal I did not give the interest charges during construction because it is such a simple and ordinary procedure; but I should perhaps have stated that any computation of interest charges for a period of construction of the sea-level canal longer than twelve or thirteen years is without any real foundation.

As has been shown, and as is indicated in the majority report, the simple character of work—i. e., excavation and transportation—required in the construction of that plan will enable the estimated time of completion to be shortened rather than lengthened, whereas in the lock plan the complicated character of the construction of the six locks and other masonry works would be likely to extend the time required for construction beyond that estimated.

In reading testimony given subsequent to mine I find some of my observations relating to the transformation of a lock canal to a sea-level canal misunderstood. I stated that it was the opinion of the board, both majority and minority, that if the recommended lock plan should be adopted the cost and time required for the transformation of that particular lock canal to a sea-level canal would be so great as

practically to preclude the procedure for an indefinite future period. In other words, the difficulties and cost of that particular transformation would be so great as to make it practically not feasible.

I stated specifically that the best lock plan, in view of future transformation to a sea-level plan, would be found by carrying the sea-level portion on the Caribbean end nearly or quite to Obispo, and on the Pacific end to Miraflores, with the lock portion between these two points. That plan would be far more easily transformable to a sea-level plan than that recommended, and the operation of transformation would involve a minimum of waste. For the reasons extensively given in the majority report and in the testimony, I believe, however, that it would be far better in every way to construct the sea-level plan at once.

My testimony regarding the silting of the channel of the lock plan in the upper reaches of Gatun Lake between Tavernilla and Obispo has been questioned. The concentration of the current in such a submerged channel as that between Alhajuela and Tavernilla, with such depths of water over the original banks as would exist in Gatun Lake, is precisely what is observed with any submerged river bottom similarly flooded in this country. It is a common hydraulic observation.

The assumption that the water moves uniformly across such a submerged valley and its use in computations of velocity of water under such conditions indicates a gross lack of familiarity with this particular class of river hydraulics, as it is directly at variance with the results of natural observation. The first Isthmian Canal Commission of 1899-1901 recognized the inevitable silting of this submerged channel with precisely the same elevation of water surface, and stated on page 63 of its report that a velocity of 5 feet per second might be reached during floods in the narrowest part of the lake.

The streams located between Gamboa and Bohio, draining a territory from 100 to 150 square miles, and for which provision has not been made for taking their waters entirely away from the canal prism, are all so small that it is difficult to make any definite estimate of even their flood discharges. This amount has been estimated by the minority as high as 29,000 cubic feet per second by taking it at one-fifth of the supposed discharge of the great flood of 1879. It should be borne in mind at the outset that there is not only no record of any such flood volume as 140,000 cubic feet per second at Bohio, but there is no reliable estimate of such a flood.

The most reasonable estimate from indirect evidence is that of General Abbott of only 112,000 cubic feet per second, which would make the maximum estimated flood flow of the small streams in question, if all were in flood concurrently, 22,000 cubic feet instead of 29,000. This freshet flow of a large number of very small streams is, however, a diffused flow from a drainage area a large portion of which is of such a character as to prevent a quick discharge. Furthermore, the diffusion of a flood flow into a great number of small streams, most of them so small as to be dry in the dry season, will practically destroy the eroding power of any floods that may occur in them, thus reducing to almost insignificant volume the silt brought down by them in comparison with the erosion which would be produced by concentrating

the total discharge into two or three streams of greater magnitude. The sedimentation basins, therefore, provided in the sea-level plan between Gamboa and Bohio, are abundantly ample to receive and retain practically all the silt brought down by the rivulets in question.

In my testimony I cited the case of the flow of water from a small underground channel at a depth of about 125 feet below the river surface above it through a boring made in the Hudson River near New Hamburg, N. Y., in the course of investigations for the additional water supply of New York City. As it was intimated in subsequent testimony that this flow was found in a boring through rock, it is well to state the fact that this water was found beneath a thick bed of clear clay a few feet above the bed rock. The water as it flowed up through the boring pipe made a fountain or jet with the water rising 15 or 20 feet above the river surface. It was a clear case of a small underground flow under pressure between two strata of different quality or texture.

In case of more or less permeable strata of varying quality overlying each other, a comparatively large amount of seepage or flow is liable to take place along surfaces of separation where the texture changes from one quality to another. This is so well recognized in the making of artificial filter beds for public water supplies that the greatest care is taken to avoid any sudden change of texture at any point in the filtering mass, because it has been observed that the water is almost certain to find its way in small thin channels wherever such a break or sudden change of texture occurs. The formulæ for the computation of flow through clear selected sand neglects absolutely any such feature as this change of texture where the freest flow takes place, and they are consequently entirely inapplicable to such conditions. As such conditions are freely found in the subsurface material at the Gatun dam site, as disclosed by the borings, it is obvious that any computations of the volume of seepage based upon neglect of the conditions found there aiding the flow must be wholly erroneous.

Much has been made in the minority report and elsewhere of the alleged necessity for tying up ships in order to pass each other when meeting in a sea-level canal of the dimensions recommended by the majority. It is to be remembered, as stated in my answer to one of Senator Morgan's questions, that the entire sea-level prism, as recommended, is a continuous passing place for ships. That part of the prism which has a bottom width of 150 feet is everywhere wider than the passing places in the Suez Canal, which have a bottom width of 147 feet 6 inches. In the 8 miles through the Culebra Cut the bottom width is 200 feet, with sides practically vertical, affording a much increased width of channel for passing purposes. Under these conditions few, if any, ships short of 550 feet in length and 55 to 60 feet beam would have to be tied up to pass each other anywhere in the canal. Ships nearly or quite up to those dimensions would pass each other by slowing their speed and still smaller ships at their regular speed.

As the great bulk of canal traffic will be carried in vessels of less tonnage than those cited above for probably a considerable number of years, it will readily be seen that there can exist but little delay to

any part of the canal traffic due to the tying up of the largest ships. Any time of passage of a ship through the sea-level canal, therefore, computed on the assumption that ships must always or generally be tied up whenever they meet and pass, as is done in the minority report, will give results entirely erroneous. As a matter of fact, as is demonstrated by traffic upon existing maritime canals in Europe, such as the Manchester and the Suez, the majority of vessels seeking the canal, i. e., except those of the largest dimensions, may pass each other, either at speed or by slowing up, but without tying up at meeting places or anywhere else.

It has been suggested in the minority report and in the testimony before the Senate committee, that in the lock plan its capacity might be increased or that facility of passage through it might be enhanced by fleet lockages, i. e., by taking two or more vessels of suitable size into one lock. While it is true that the matter of fleet lockage may be advantageously resorted to when a single lock only exists, as at the Soo, the time of lockage even there is greatly extended by the time required to properly place the two or more vessels brought into the lock at the same time with sufficient closeness without injuring each other, either when brought in or during the emptying or filling of locks.

When, on the other hand, there is a series of locks of either two or three in flight, the operation of moving a number of ships from one lock into the next one below or above must be made with extreme caution and very slowly, in consequence of the increased danger of injuring both ships and gates. No reliable computations can be made as to the greatly extended time required to pass the triple locks in flight at Gatun or the double locks in flight at Sosa Hill in case it should be considered prudent to attempt fleet lockages, as it would depend upon the number and size of ships admitted into a lock. The requisite time, however, would be extended much more than in proportion to the number of ships being locked, as would also the danger with which both vessels and structure would be threatened. Indeed, it would become a grave question whether this system of lockage could be permitted for any vessels whatever in such a flight of locks, except possibly for those of the smallest tonnage.

In connection with my testimony concerning the advisability of shutting off underground seepage through porous strata under an earth dam, I would like to mention the fact that the Charles River dam now being built at Boston is an earth dam. The maximum unbalanced head of water which it will have to retain is that due to the tidal range only in Boston Harbor. The plans for that structure, which I have before me as I write, show that a line of close sheet piling, called a shut-off dam, is driven along that part of it resting on substrata of sand and gravel, so as to preclude any possibility of seepage under the dam itself. Mr. F. P. Stearns, a member of the minority of the Consulting Board, is the consulting engineer for this construction.

The general principle recognized in placing this sheet piling subsurface cut-off in the Charles River dam is that which almost or quite universally governs the construction of great earth dams at the present time, by either placing them upon absolutely impervious material

or carrying a curtain construction of some kind, such as a masonry core, a clay core, a line of close sheet piling, or some other device of that character, down through the permeable strata to bed rock or its equivalent, so that all subsurface seepage or underflow can be effectively prevented.

I trust this letter can be admitted as a part of my testimony.

Very respectfully,

WM. H. BURR.

Hon. J. H. MILLARD,

*Chairman Committee on Interoceanic Canals,
United States Senate.*

STATEMENT OF LINDON W. BATES

**BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.**

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Saturday, March 10, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Hopkins, Knox, Ankeny, Morgan, and Taliaferro.

STATEMENT OF LINDON W. BATES.

The CHAIRMAN. Mr. Bates, state your full name, residence, and occupation, please.

Mr. BATES. Lindon W. Bates; residence, New York; occupation, civil engineer and contractor.

The CHAIRMAN. I understand that you are ready to proceed, and I believe that you have your statement prepared, so that we will endeavor to let you go along without interruption until you have completed your statement.

Mr. BATES. I would say, Mr. Chairman and gentlemen of the committee, that I have this morning things to say to you which are quite different from anything that you have so far listened to, I believe. I want to say at the outset that I have criticised things, and not men; official acts, and not individuals.

I was born in 1858, and am 47 years old; was educated in the Central High School in Chicago and the Sheffield Scientific School at Yale. The speaker began work in 1877 with the Chicago, Burlington and Quincy, but after a few months went to the Pacific coast, where he served as engineer with the location and construction forces of the Northern Pacific, Oregon Pacific, and Oregon Railway and Navigation companies. Presently he entered business independently as a contractor, and executed constructions in Oregon, Washington, and other parts of the West. At Kansas City, in 1885, he changed the mechanism of a new dredge that had failed, and executed the reclamation of the Kaw, where the stock yards now stand.

Next, he built a larger machine, which was destined for lower California, but which was taken instead to a contract on Puget Sound. There he reclaimed the land for the Northern Pacific terminals, damming the Puyallup River there. The Puyallup dam was the first one ever made with a hydraulic dredge; the year was 1888. At Portland, Oreg., he filled from the Willamette the terminals for the three Pacific railways centering there. These included a raised dike across Guilds Lake to carry the main line of the Northern Pacific, which was the second damlike embankment to be made with a hydraulic dredge.

By this time, 1892, he believed that the best elements had been worked out, one by one, from experience and experiment, for the most successful type of dredge. He went to Chicago and contracted in 1893 on sections A and B of the drainage canal, building for use there two small hydraulic dredges on new lines.

A member of the board of consulting engineers, in recommending this type of plant, states, regarding these two pioneer machines (p. 405):

"You will note that in several instances I suggest hydraulic dredges for removing material overlying rock. This is in accordance with my experience on sections A and B of the sanitary district of Chicago, where we used two hydraulic dredges," etc.; and, again, "employed in the construction of some important dams in the western part of the United States."

It is of import that the experience here cited is that upon which some hydraulic-dredge possibilities are recorded. It considers two of the writer's pioneer machines of 1893 of 300 horsepower.

On page 69 of the minority report is given the process for constructing the huge dam of 21,000,000 cubic yards. This dam is the heart of the minority's design—one of the two central elements by which its canal must stand or fall.

The process reads (p. 69):

"The lower part of the dam up to elevation 50, or even to elevation 80, is to be made from material dredged from the canal between the Gatun locks and Limon Bay, pumped by a suction dredge into the dam," etc.

This system received from the chief engineer of the canal full indorsement. His examination before your body reads (p. 900, Senate committee's report):

"The construction that is proposed for that [dam] is not to pile that dirt in there largely from railroad trains, but to take it from the mass that is excavated here by dredges, bring it up to that point, and pump it with hydraulic pumps from the barges or drop it into a basin and pump it from there into the dam."

The speaker, since this date of 1893, has devised and constructed hydraulic excavators up to 5,000 horsepower. Yet these, his very latest machines, the most powerful dredges ever attempted in the world, could not perform the task set them here by the minority. How and why he will presently show. He reverts now to the history.

In 1894 he was invited, among several others, by the Mississippi Commission to submit designs for a dredge for the mechanical removal of the bars, which \$36,000,000 sunk in training walls, etc., had failed to remedy. The proposals were to be competitive. The machine must deliver 1,600 cubic yards per hour—three times what had ever been done before. A premium was promised of half the cost if this output could be raised 50 per cent. He built the *Beta*, which delivered over 5,000 cubic yards an hour, and was awarded the full premium of \$87,000. That output has never since been reached in America. The art has remained here stationary—exactly where it stood eleven years ago.

The *Beta's* record, 800 per cent above the nearest second, revealed to him that a new era was about to open in the science of waterway improvement. He felt that he could construct the first requisite—

the tool. He believed that Europe afforded a wider field of opportunity, and he went abroad in the summer of 1896.

BELGIUM.

In the autumn there were arranged for him joint conferences with premier and minister of public works of Belgium. There was under consideration there the largest national public work then contemplated in Europe—the Grande Coupure of the Scheldt below Antwerp. General Brialmont, Sir John Hawkshaw, Maas, Stoessel, and others had already made designs for it. The speaker stated to the minister that time and cost could both be materially reduced by new methods. He was invited to prepare and submit a plan as the city of Antwerp and the central Government had quite different views. In due course this was submitted. He then learned a fact of which he was unaware, that some time before the ministry had privately requested a design for this great work from Oberbaurath Ludwig Franzius, of Germany.

The Oberbaurath was the father of that monumental triumph in engineering—the Weser River regulation. He was conceded to be the greatest living hydraulic and harbor engineer. The Bates project was sent to him by the minister for a report. Its general points were found to be identical with the German's. But there were certain important differences in adjustments, alignments, and methods of economizing costs, which the new tool for the first time made possible. The Oberbaurath, too supremely high to fear any insecurity or competition, wrote this magnanimous summary: "I associate myself with the conclusions of Mr. Bates." Through all his European experience no friend extended a more encouraging and generous hand than this first and greatest critic.

The project was next submitted to the Belgian committee of National Ponts et Chaussées. They likewise indorsed it. But before the minister would engage his approval a commission of two engineers was appointed to proceed to America, investigate and report. The report was published in the *Annals des Travaux Publics*, the official organ of the Government, in March, 1897. Upon delivery of its verdict the premier gave his approval. The investigation committee's report was sent for later by the Russian Government when a commission given him made knowledge of his credentials imperative there also. The Grande Coupure, owing to its financial side, was taken from the technical to the political arena. Now, however, the improvement increased to \$50,000,000 has just been voted by the Belgian Chamber of Deputies.

Subsequent to this he spent many months traveling, to inspect at first hand the European rivers and harbors and to study the engineering treatments that were in progress to secure the fullest service to navigation. He visited every port of prominence in Europe and North Africa. Later he had business reasons to visit India, Australia, the Philippines, China, and Japan. He came thus into actual personal contact with the experiments, the failures, and the successes of nearly all the world's great ports and waterways.

RUSSIA.

In the winter of 1897 Prince Hilkoﬀ, minister of ways and communications of Russia, commissioned him to study the Volga and report upon the deepening of its bars. Later the minister extended

the commission to include the Black Sea ports. He was to design improvements, having reference not alone to their commercial, but, also, to their military service. A naval officer was detailed to accompany him and get from the departments of the various places the data required.

His report to Prince Hilkoff examined and designed improvements for the Volga bars, the possible enlargement of the canal system Marie, the Volga mouths of the Caspian, and the Russian mouth of the Danube, together with the Black Sea ports of Rostoff on the Don, Taganrog, Kertch, Nicolsiev, Kherson, Odessa, and Ackerman.

Subsequent to these presentations the Russian Government ordered a fleet of dredges for use on the Volga bars. They were constructed by one of the largest works in Europe, the Soci   Cockerill, of Seraing, Belgium, who are still his continental builders, according to his designs and under his personal direction.

There came to these trials a commission of three sent by the German Government, then discussing the Great Central Canal; a committee of one sent by the Suez Canal, already then being pressed by ship-owners and the English authorities for enlargement; another of one from the Manchester Canal; three engineers sent from the Oberbaurath's Weser River board, four men of English harbor boards, one committee of three from Australia, ten representatives from France and the French ambassador, two from Austria and its ambassador, one from India, one from Siam, four from Russia and its ambassador, the Turkish ambassador, one from the Danube, and hundreds from Belgium itself. So general was the interest that for some days of the last week the State railways ran excursion trains to accommodate the numbers who wished to inspect and see these tests.

There had been offered a premium of 150,000 roubles if the machines would reach a stipulated output under rigorous conditions. The trials were exacted in duplicate, one series on the Scheldt and one at St. Petersburg, but when the output on the Scheldt went 200 per cent above the requirement the full premium of 150,000 roubles was paid. A recent letter from Prince Hilkoff states that these machines were giving satisfaction, and that the unit cost upon Volga bars was the lowest of any method tried. The Russians were engaged on the Volga and at Kherson, Nicolaiev, and other ports, in accordance with the recommendations, when the war broke out.

QUEENSLAND.

In 1898, before the Russian order was filled, the speaker was called to Queensland, Australia, by its government to examine the harbor and river of Brisbane. On his arrival several of the other ports up the coast sent to the home secretary a request that their ports be included. He was finally asked to examine and make projects for nine ports connected with their five rivers. He prepared designs for the Brisbane River and Harbor, for the Fitzroy River and Rockhampton Harbor, for Bundsberg, Townsville, Mackay, Cairns, and the Norman and Albert rivers of the Gulf of Carpenteria, etc.

On the Fitzroy River there is now being constructed a great system of training embankment by the same hydraulic dam building process which the minority propose to employ. The writer's dredge, *The Archer*, is pumping the material from the bottom of the river

into dam-like embankments. He is himself in consultation, giving the directions for the construction. He knows, therefore, here from first-hand intimacies of execution, the ruling facts of which he will presently speak. He has himself tested and experienced the limitations.

SOUTH AUSTRALIA.

In 1901 a parliamentary report was made for the South Australian government. The other ports of the colony here also asked to be included, and he was finally bidden to prepare projects for six harbors, for a proposed extension of the railway system, and for a navigable access to the Murray River. There was included in the report a design for the outer harbor of Port Adelaide. This had been a technical and political controversy which had gone on for more than a generation. He designed improvements also for Largs Bay, Port Victor, the Murray mouth, and Kingston Harbor.

The construction of the outer harbor of Adelaide has been now three years under way, and at Brisbane, Rockhampton, Largs Bay, and numbers of smaller places works are being continuously prosecuted and executed.

INDIA.

Upon the invitation of the chairman of the Calcutta port board, the speaker made an exhaustive examination of the bars of the Hooghly. He designed a method of treatment and improvements for the river and certain works for the harbor.

The harbor board at Bombay, about a month ago, sent him a request to make up for them a project involving 25,000,000 cubic yards of combined reclamation and harbor improvement.

In Queensland, in South Australia, in Calcutta—indeed, in almost all these countries—the Government forces of engineers, draftsmen, etc., were put at his disposal to collect data and to do the details of the work.

EGYPT.

He had been for some time in correspondence with the authorities of the Suez Canal, whose meager dimensions had long been a source of discontent to English merchants. Sir John Stokes, an English member of the board, recognizing that the passing of the *Hercules* to Australia would give a very favorable opportunity for settling the much-discussed question of cost and facility of canal enlargement, enlisted the interest of Mr. Joseph Chamberlain, then colonial secretary. At Mr. Chamberlain's request the Queensland government granted permission for the dredge *Hercules* to halt on her way out and make in the Suez Canal a demonstration of what the new order might or might not accomplish. These Queensland dredges had been built by the Sir William Armstrong Whitworth Company (Limited), of New Castle-on-Tyne, who are still his English builders. The Suez has many varieties of material, among them a very dense and tenacious mixture of clay and gypsum. Since the Australian machines were built to handle sand alone, costs could not be expected to reach their minimum or capacity to reach its maximum, but certain safe approximations could be reached. Here was a chance to study one great sea-level-and-lake canal over water and under water.

In Egypt, at the invitation of the English minister of public works, Sir William Garsten, he went up the Nile and made a report upon the treatment of its bars and the approaches to the new lock at the Assuan dam. He made also, for the same minister, an examination of the Sudd question south of Khartoom, and the possibilities of carrying a railway embankment across the Bahr-el-Ghazal. In consequence he was at Assiut and at Assuan during the construction of those two monumental dams, whose principles are incorporated into his project. The Assiut Barrage of Egypt supports on alluvial foundations a 40-foot head of water. But the Assuan, on rock foundations, is the model for the writer's similar sluice barrages on the Panama Canal. The Assuan dam controls the floods of the Nile, which are six times those of the Chagres. This is likewise the model for his Gamboa, Alhajuela, and Cano under sluice dams.

Senator MORGAN. What are the foundations underlying the pier at the Assuan dam?

Mr. BATES. Granite.

Senator MORGAN. You have gone down to granite everywhere?

Mr. BATES. Yes, sir.

Senator MORGAN. How deep?

Mr. BATES. About 45 or 50 feet.

Senator MORGAN. Below the surface of the Nile?

Mr. BATES. No; that was after the water was drained off. That was below the surface of the land.

CHINA.

Later the speaker went to the Philippines and China. He visited the latter country twice, for here, on agreement with an English company, he had arranged to examine the problem of the lower Yangtse and seek some better system for getting transports up the river and the 350 miles of gorges.

He examined also, while in China, and prepared plans for the Whang Pu. The Chinese call its bar their "heaven-sent barrier," and Europeans for fifty years have been trying to get it remedied. It may be recalled that one of the stipulations in the treaty of peace closing the late Boxer rebellion was that the Whang Pu River should be made safely navigable.

On his return to Europe he received a letter from Oberbaurath Franzius asking his collaboration. The letter states that the German Government had, before the signing of the treaty, bidden the Baurath study the Wang Pu and make them a project for its relief. He suggested that since Mr. Bates's proposed treatment coincided with his own they unite an alliance of representatives from other countries to make an international board. This was done. The members included Prof. W. H. Wheeler, M. I. C. E., of England, a leading author and authority on tidal rivers; George De Thierry, German Government member of the board of the Suez Canal and professor of hydraulics in the University of Berlin; Von Weber Ebenhoff, of Austria, professor of hydraulics in the University of Vienna; J. H. Apjohn, esq., M. I. C. E., builder of the famous Kiddepore docks, at Calcutta; M. Duforny, chief engineer of Ponts and Chaussées, of Belgium, designated by his own Government, and the late M. Zakaroff,

builder of Dalny, designated by the Russian minister of foreign affairs. The project thus accredited is before the Chinese Government.

JAPAN.

The speaker also twice visited Japan, going three times along the coast by water, stopping to study the ports, and once through the interior to inspect the country.

The writer is a member of the Western Society of Engineers, of the Civil Engineers of France, of the Civil Engineers of Belgium, of the Institute of Naval Architects of London, and other technical societies.

GALVESTON GRADE RAISING AND ERIE BARGE CANAL.

Later the speaker returned to the United States and established an office in New York. Galveston was proposing to raise its city grade. Your committee will recall that the town in 1900 was swept by a disastrous tornado which cost its population 6,000 lives and a property loss of \$34,000,000. A sea wall of concrete was built along the Gulf front. But the authorities decided to insure against all possible recurrence by lifting the city bodily above the flood line.

The problem became how to bring material for the district to be filled. To fill by cars was so costly as to practically rule out this method. The quantity (12,000,000 cubic yards) was three and a half times that removed from the New York subway. Water and gas pipes, street-car lines, houses, etc., had to be kept available for continual use. No dredge could pump the distance and height necessary. Two hundred and fifty contractors were invited to tender. Two contractors did tender. The speaker devised a method of driving a canal into the heart of the city and then, by use of a type of self-propelling dredges never before employed in this country, bringing in material and distributing it. The speaker's bid for the work was 40 per cent below that of his one competitor. The Galveston grade raising is now well advanced. The sand under the plan devised is taken from the Government channel, incidentally creating an improvement to it of \$1,500,000 value.

The recent New York barge canal law dedicated \$101,000,000 to the new Erie Canal. There have been let at this date six sections. Of these the company of which the writer is president has three, aggregating 21 miles of canal length. This construction includes rock excavation, earth work, piling, concrete masonry, dams, etc. Two dredges of 1,000 horsepower each and a large amount of other plant are under construction for it at the New York Shipbuilding Works. There has been introduced on it the first Lobnitz rock cutter ever used in America.

This company has just been awarded the Buffalo port-improvement work undertaken for the United States Government.

Senator KNOX. What is the name of your company?

Mr. BATES. The Empire Engineering Corporation.

Discussion of Panama Canal projects.

NEW SEA-LEVEL MAJORITY OF CONSULTING ENGINEERS—85-FOOT LAKE-
LEVEL MINORITY OF CONSULTING ENGINEERS AND CANAL COMMIS-
SION—SYSTEM AND PROJECTS OF LINDON W. BATES.

DISCUSSION OF ATLANTIC HARBOR PLANS.

[Diagrams on supplemental sheet, Fig. I, majority plan; Fig. II, minority; Fig. III, Lindon Bates.]

Both of the harbors recommended by the advisory engineers are inclosed by an east-and-west breakwater. Both are approximately parallel to the axis of Limon Bay, but are toward the east or Colon shore.

The *east breakwater* is common to both schemes—an arm run out to the 40-foot contour from Manzanillo Point. Immediately off its outer end and only a few hundred feet to the northward is a dangerous cluster of rocks and reefs carrying but 22½ feet of water. These in “norther” break heavily and induce a jumble of swift currents and backwash, hazardous to a steamer seeking haven in dark and stormy weather. The Board is united in presenting as a harbor feature this perilous reef right under the lee of wind-lashed vessels. Ships that in storm or blinding rains miss the narrow entrance ought to have sufficient sea room to avoid piling onto such hidden jagged peaks, but this would mean approximating the entrance to Harbor III. Safety to navigation should be a keynote in the harmony of the best canal scheme.

Further, the Board’s mile-long eastern arm receives the high trade-wind waves, driven often by vicious squalls, not at right angles to its axis, but obliquely.

The West Indian “norther” and hurricanes and gales come nearly always not out of the north, but from about the north-northwest. This condition of wave exposure compels, for the breakwater, a large cross section and extra heavy blocks of stone or concrete, else the fiasco of the early Galveston jetties must be but repeated.

WEST ARM.

The majority indicate a west breakwater 3½ miles long from Mindi point. The minority one 4½ miles long from Mindi mouth. The sailing course here is almost due north.

The West Indian “norther” comes nearly always (as was noted) not out of the north, but from about the north-northwest. This is why Toro Point partially shelters the safest anchorage in Limon Bay. The charts of all nations show this and all admiralities officially admonish mariners of it. To this shelter vessels first scurry from the danger of reef-bound Colon. The eroded shore contours of Manzanillo Island bear evidence of the inroads of past cyclone-made breakers. Do these attested facts and the deep mud bottom mean nothing to the course, design, construction, and maintenance of at least the outer 3 miles of the west arm? The minority (p. 68), the Commission (p. xviii), and the chief engineer (p. xx), before undertaking these, their planned breakwaters, have misgivings. They all make reserves and would wait and experiment with the situation for

some years. Crested rollers at least 25 feet high must assail obliquely the 3-mile flank of the west arm, founded in mud. Solid 20-ton rock blocks are not obtainable on the Isthmus, with which to make safe these sponsored and half-sponsored and temporized harbor-defending walls. They stretch $4\frac{1}{2}$ and $5\frac{1}{2}$ miles long. But no one ventures to even guess at the heights from their crests to the deep unknown mud-buried bases of their outer 3 miles. Is it meant to bring granite from the States? Are concrete blocks intended? There is neither sand nor concrete available. It would take argosies of ships to carry sand, cement, or 20-ton blocks of stone from any source of supply. This is the breakwater situation.

Neither party, though the Spooner act calls for adequate and equipped harbors, presents a design or vouchsafes a detailed estimate. Both use the same round sum, \$5,000,000 (majority report, p. 58; minority estimate, p. 425). Though the writer's figures are characterized as over low, he observes that the minority for the inner end employ a unit price which is *half* his own. (P. 425, minority item, gives \$0.75 per cubic yard, and Bates's, p. 264, item 23, \$1.50 per cubic yard.)

The majority and minority, after these long breakwaters and reef-bound entrances, have here a salt harbor only and a terminal city 2 miles from the best canal entrance built over an unfilled swamp. If the terminal were removed under their plans to Mindi, it would still remain surrounded by morasses.

A personal inspection of the head of Limon Bay convinced the writer that Mindi is the best canal entrance when properly defended. It eliminates two sharp curves and shortens by several miles the total canal length.

Jaramillo Hill, between a fresh-water lake and Limon Bay, is the best location for the terminal city, and a course nearly midway across the bay the best approach to Mindi from the bay entrance.

The approach in Limon Bay—shown on the plate (Fig. III), was chosen by the writer because:

First. The 45-foot contour of deep water came farthest into the bay there according to the charts then existing. By the Coast and Geodetic Survey chart, completed November, 1905, the 45-foot contour is seen to be almost equally distant from Mindi by any approach. So this first reason for the approach as planned by the writer is no longer leading, but it is still retained because of his additional three reasons:

Second. This location is well away from the dangerous reefs.

Third. It gives a curveless entrance to Mindi.

Fourth. It points into the eye of the heaviest winds and wave motions, not somewhat obliquely as in the majority and minority approach.

The open approach through Limon Bay to the short inner breakwater founded in shallow water is subject to one question—resilting. There will be so little of this that dredging is better than building expensive breakwaters or jetties.

First. No river will enter the bay; hence there will be no river deposits.

Second. There is no evidence of any littoral drift to speak of. Having eliminated these, there is left only the deposits to be expected

after a heavy storm. Large hopper dredges will keep an approach deep and wide for far less than the interest and maintenance of the harbors created by the Board and minority's $3\frac{1}{2}$ and $4\frac{1}{2}$ mile breakwaters.

The channel proposed by the Board and minority is but 500 feet wide. The channel advocated should be 600 feet wide to the basin below the Balboa lock. Six hundred feet, in an exhaustive examination made at Durban, South Africa, was considered by the authorities the least that should be provided for a harbor-entrance channel. It is expected that the works of maintenance will gradually enlarge the Bates channel to the preferred width of 1,000 feet.

Senator HOPKINS. You say 600 feet is the limit. Do you give the reasons anywhere in your statement that you are now making?

Mr. BATES. Yes, sir; you will find those later. I will say that that examination was made by Sir Charles Hartley and others, and the Durban entrance is one of the most difficult entrances in the world to maintain.

Senator HOPKINS. You are making that suggestion, as I understand it here, as a criticism upon the recommendation of the 500 feet by the majority and minority report of the engineers here?

Mr. BATES. Yes, sir; it is a navigation question of the passing of ships under steam.

Senator HOPKINS. You set out somewhere in your statement the reasons in detail why the 500 feet will not do and why the 600 feet should be adopted?

Mr. BATES. Yes, sir.

Five hundred feet is too narrow for very large ships to pass each other safely without reduced speed, whether going in opposite or in the same directions.

In the Balbot location there will be first of all a well-protected salt harbor. The city will be newly and properly built from the beginning upon American soil; not upon that of Panama. Its site will be healthy. Protected behind Jaramillo Hill on the fresh-water lake there can be an impregnable naval station. There will be also here the fresh-water harbor—Lake Chagres.

The superior safety, usefulness, and convenience of Balboa Harbor and approach and basin to merchant and naval vessels can not be disproved, and it will cost far less than the other proposals. By their own figures, which, as has been shown, are seriously underestimated, the breakwater of the majority costs \$5,000,000; that of the minority, \$5,300,000; that of the writer, \$1,000,000, exclusive of dredging.

Senator HOPKINS. If it does not interrupt the thread of your discourse, I would like to have you point out here on your maps the situation as proposed by the minority and majority and yourself, so that we can get a picture of the situation where you are going to save over four millions, according to your statement.

Mr. BATES. Yes, sir. That is the harbor terminus of the minority [indicating on map]; this is the harbor terminus of the majority, and here is the harbor terminus which I have recommended, an outer approach here, and, in about 20 feet of water, a breakwater there, defending the approach to the basin in front of the lock. That gives you, then, the three ideas.

Senator HOPKINS. Do those black lines across there indicate a proposed breakwater [indicating on map]?

Mr. BATES. That is simply what I used in the discussion as being a breakwater that I would not construct; but I would construct this one by preference [indicating on map].

The CHAIRMAN. Mr. Bates says that if you will permit him to get through with his statement he will explain all these features. He would like to continue until he finishes his statement.

Mr. BATES. Yes; when this is printed there may be questions to be asked, and they can be more easily answered at that time.

EXCAVATION FROM MINDI TO GATUN.

The majority excavates along the old canal line, digging down to 40 feet below sea level. The minority cuts a new line through a series of hillocks made of hard clay. They both figure upon digging the "indurated clay" or "clay rock" with a hydraulic dredge.

Inquiry has developed the fact that except at the intersection at the mouth of the Mindi the minority had in hand from there to Gatun, a distance of nearly 4 miles, not a single boring on which to base the estimate to which all their responsibilities are attached. There exists neither a profile of the surface nor one of the indurated clay. Their new line is away to the eastward of all the canal excavations of the French company, and therefore away from all accurate knowledge of actual strata.

Senator HOPKINS. How far away is it? You say they had the French borings that covered that. Now, how far is the proposed line of the minority, where you say there are no borings?

Mr. BATES. It varies from nothing to about half or three-quarters of a mile.

Senator HOPKINS. Is the formation there such as, in your judgment, to require additional boring at that distance?

Mr. BATES. Yes, sir; and as I read on I will show you why.

Senator HOPKINS. Very well.

Mr. BATES. The majority concede 2,357,154 yards of refractory material in their own line to mile 5.49. The line of the minority is closer to the Sierra Quebrancha Hills; hence it is certain naturally to encounter *more* refractory material. But its sponsors claim to have in their excavations between Mindi and Gatun *less* indurated clay than that which the majority concede. The writer declines to credit that the minority has figured in enough refractory excavation. He concludes from a careful study of all available data that between Mindi and Gatun especially the quantities allowed by the minority are far too small.

From an examination of all pertinent maps and a familiarity with the history of the abandoned French diversion, and from the accuracy of the data of the majority on the old canal alignment, remembering that on this section the minority project is *over three times* as wide as the sea leveler's project and runs amid clusters of small hillocks, it becomes almost a certainty that the indurated clay in the minority's estimates is vastly underrated, but by what amount no one knows. When the line is actually surveyed, if it ever is to be, and bored, it will undoubtedly be found that they will have *over double* as many cubic yards as they now contemplate of clay, refractory from a dredging standpoint.

Senator MORGAN. What do you mean by "refractory" in that connection?

(Mr. Bates exhibited to Senator Morgan a piece of indurated clay obtained from one of his borings.)

Senator MORGAN. I can not tell by looking at it. Can you describe it?

Mr. BATES. I mean that the capacity of the dredge will be so much reduced that the unit cost will be very high.

Senator TALIAFERRO. Is that one of the borings [referring to specimen of clay exhibited by Mr. Bates]?

Mr. BATES. Yes, sir.

Senator MORGAN. Why do you call it refractory?

Mr. BATES. I use that word from a dredging standpoint, as meaning a class of material which is exceedingly difficult to handle.

Senator MORGAN. Why is it difficult to handle?

Mr. BATES. Because a dredging operation consists in the first place of severing the material from its bed, and then in lifting it, and then in distributing it. In severing material from its bed sand is very easily severed, a certain variety of clay is severed with very great difficulty, and rock may have to be blasted.

The curve between Mindi and Gatun must be over 700 feet wide at the water line, and this expanse of indurated clay is located right on top of the hard, hilly knobs which stopped the French diversion excavations. The amount of indurated clay and rock is therefore manifestly underestimated. The minority merely guessed at it, for they had no borings or even surface-profile data.

Senator MORGAN. Your project has a dam across the Chagres River and the Gatun project also has one. What is the distance between the two projected dams?

Mr. BATES. Senator, I have a dam at Mindi and another one projected at Gatun. The one at Gatun is on the same axis as that proposed by the minority.

Senator MORGAN. The same axis exactly?

Mr. BATES. Exactly.

Senator MORGAN. Very well.

RECEPTION BASIN BELOW GATUN FLIGHT.

The minority report does not provide for a waiting basin below the locks, and their 500-foot waterway is inadequate for the reception of ships without one. The chief engineer points out this omission on the part of the minority. The writer, you will note, provided it in his presentation. The chief engineer remarks (letter, Jan. 26, 1906, p. 20):

"I believe, however, that the construction of a large basin or inland harbor at or near Mindi, or at a convenient location which exists below the Gatun dam, such basin to be supplied with coaling and other proper outfitting facilities, will be found advisable; the material excavated in the construction of such a basin is to be used in the construction of the Gatun dam."

This widening is needed near the locks. There it will be a mile or more from the lower margin of the Gatun dam. It will be thus beyond the limits of direct hydraulic dredge-pipe distribution and lift to the height required for utilizing its material in the dam. This

basin will have to be excavated last, after the channel reaches its location; otherwise a special channel half a mile long must be dug to it eastwardly from the old canal, in order to give the floating plant water access to the area to be dredged. Such a canal will likewise cross and interfere with the Panama railroad.

The material dug from this widening must therefore be transported in the same fashion as all the rest of the approach to the Gatun locks, viz, by scows. They must be towed back down the newly dug channel and then up the old canal or through an expensive and inconvenient cross channel. This has not been estimated either. Some of the material might be pumped *twice* to get it to the foot of the dam, first into the old canal bed and then into the lowest parts of the structure; but the quantity of direct excavation and distribution that can be done by such a method is limited to a relatively unimportant amount by the great length of the dam and the height to which the material must be hydraulically lifted.

The writer consistently sought to avoid, and did avoid, having to dredge much "indurated clay" and "Mindi rock."

The Board adopted some unit prices, which assign to this material to be dug by an "hydraulic dredge with cutters" 70 cents per cubic yard. Board report, page 419:

"It must be remembered that any estimated price is necessarily only approximate and should be made high enough to guard against errors, and will then be high enough to cover small variations from average conditions. It is recommended that the prices be used broadly."

Dredging:	Cubic yards.
Mud and sand in Colon and Panama harbors.....	15
Soft material removed by hydraulic pumps in canal.....	25
Indurated and hard clay requiring cutters.....	70

In the Colon Harbor bids last summer one firm, practical and experienced in the art of dredging by suction and with other types of dredging machines, spent months of time and thousands of dollars investigating and boring. Annual Report Isthmian Canal Commission (p. 251):

"The chairman read a communication from the chief engineer, dated December 29, 1904, respecting the conduct of Mr. C. W. Sturdevant, agent of the Atlantic, Gulf and Pacific Company, who had been given permission and assistance in taking borings and gathering special information regarding the harbor at Colon, asking in reference to course to be pursued when such agents decline to return the courtesy and refuse to give data so obtained. The matter was referred to the chairman for reply."

Then in a competitive tendering, for which this company thus fully prepared bid \$1.50 per cubic yard (vide Engineering Record, June 24, 1905), another bidder with no serious basis of preparation nor time enough accorded bid 76 cents.

QUANTITIES AND PRICES, OUTER APPROACH TO GATUN.

The writer set forth a price for outer and inner dredging of 0.167 cents; the majority and minority allow but 15 cents per cubic yard (vide pp. 50, 262, and 425). The writer spread his 0.017 cents over 20,600,000 cubic yards, which makes thus \$350,000, or ample for the

extra cost of handling by special methods and mechanism the deposits of refractory material underlying the soft upper strata between the shore and Balboa or first lock on the line he selected.

The following are the comparative excavations as estimated to Gatun:

Comparative table of excavations to Gatun.

[From report of advisory board.]

Project.	Earth.	Indurated clay.	Total.	Remarks.
<i>Sea level.</i>	<i>Cubic yds.</i>	<i>Cubic yds.</i>	<i>Cubic yds.</i>	
0 to 3.92.....	2,781,668	5,566	2,787,234	Pages 50-51.
3.92 to 5.49.....	7,695,885	2,351,588	10,047,473	Pages 50-51 (23 per cent clay).
5.49 to G.....	(?)	(?)	2,905,000	Estimated 1,750,000 per mile.
Total	(?)	(?)	15,739,707	10 to 5.49 official. 15.49 to G estimated.
<i>Minority.</i>				
0 to 4.55.....	8,300,000		18,300,000	Page 425, report.
4.55 to G.....	10,000,000	2,030,000	12,030,000	
Total	18,300,000	2,030,000	20,330,000	
Bates.....	20,600,000	a \$350,000	20,600,000	Page 262, report.
Naval basin.....	1,500,000		1,500,000	
Clearing old canal to Mindi.....	1,000,000		1,000,000	Page 264, report.
Total	23,100,000	a \$350,000	23,100,000	

a Extra allowance.

An analysis of the conditions and of this table shows that in the Bates project the estimates to Gatun for total excavation are higher than in any other. But the dredging character of this excavation has been so beneficially diminished by putting the first lock and dam at Mindi, thus creating a lake, that but \$350,000 has had to be allowed for handling refractory clay.

The majority has against this, 2,357,154 cubic yards, at 70 cents equals \$1,950,007, and the minority has against this, 2,030,000 cubic yards, at 70 cents equals \$1,421,000.

It is a safe conclusion that the estimates of the Board, and especially of the minority, for this sea-level end work are quite *two to three million dollars* too low. The minority apparently allowed nothing for the needed reopening of the old canal near Mindi mouth, for which the estimates of Project B provided \$150,000.

The lake between Balboa and Gatun in Project B purposely eliminates nearly all canal dredging between these points. What must be done is of the upper soft material. Hence it follows that up to Gatun the Bates estimates are far safer than the others and are correct as contract rates.

THE GATUN DAM.

The official description of the minority reads as follows:

Board report, page 69: "It is intended that the downstream toe of the dam for about 200 feet shall be composed of rock obtained from excavation in the canal prism, so that if there should be any seepage of water through the dam, there will be material at the toe which can not be washed away. *The lower part of the dam up to elevation 50, or even to elevation 80, is to be made from material dredged from the*

canal between the Gatun locks and Limon Bay, pumped by a suction dredge into the dam, the process being similar to the sluicing process employed in the construction of some important dams in the western part of the United States. By this process it is feasible, when using a material like the alluvial material at Gatun, which contains both coarse and fine material, to separate the two and to deposit the coarser material toward the downstream slopes, forcing the finer material to the extent desired into the upstream portion of the dam. An embankment built in this way will be water-tight."

"For the upstream slope rock obtained from canal excavations will be dumped as riprap, care being taken to provide an ample thickness at and near the level where the dam will be exposed to wave action. The portion of the dam above elevation 80 will be built of impervious material to a few feet above the water level, and at higher levels may be made of either earth or rock, as most convenient. It is expected that for the upper part of the dam spoil from the Culebra cut will be used."

An analysis of the foregoing (for their detailed estimates, see p. 425) shows, with reference to the works of the +85 plan, that—

First. There is to be dredged to Gatun—

	Cubic yards
Mile 0 to 4.55 (Mindl)-----earth--	8,300,000
Mile 4.55 to 7.15 (Gatun)-----do-----	10,000,000
Mile 4.55 to 7.15-----clay rock--	2,030,000
Total-----	20,330,000

Second. There is to be pumped into dam from barges—

	Cubic yards
To elevation up to +50-----	12,170,000
To elevation up to +80-----	5,770,000
Total-----	17,940,000

The balance of the dam, 3,260,000 cubic yards, is to come from the lock site and other sources like Culebra.

Thus, we see that 17,940,000 cubic yards are to be dredged, put into barges, taken to the foot of the dam, and "pumped" to the stated elevations.

The detailed estimate is this (Board report, p. 425):

Excavation of channel in Limon Bay, 40 feet in depth below water and 500 feet wide from mile 0 to mile 4.55:	
Earth (dredging), 8,300,000 cubic yards, at 15 cents-----	\$1,245,000
Excavation 40 feet in depth below water and 500 feet wide from head of Limon Bay (mile 4.55) to northerly end of Gatun locks (mile 7.15):	
Earth (dredging), 10,000,000 cubic yards, at 25 cents-----	\$2,500,000
Indurated clay (dredging), 2,030,000 cubic yards, at 70 cents-----	1,421,000
	8,921,000
Excavation for Gatun locks (mile 7.15 to mile 7.74):	
Earth, 920,000 cubic yards, at 40 cents-----	368,000
Indurated clay, 2,740,000 cubic yards, at 70 cents---	1,918,000
	2,286,000
Gatun locks exclusive of excavation and approach walls-----	13,075,000
Approach walls of Gatun locks-----	500,000
Back filling and embankment, Gatun locks, 660,000 cubic yards of borrowed earth, at 50 cents-----	330,000

Gatun dam:

Earth embankment—	
Below elevation 50, 12,170,000 cubic yards of dredged material pumped into dam, at 20 cents	\$2, 434, 000
Between elevation 50 and elevation 80, 5,770,000 cubic yards of dredged material pumped into dam, at 30 cents	1, 731, 000
Above elevation 80, 3,260,000 cubic yards of material from excavations placed in dam, at 25 cents	815, 000
Excavation for diversion channel and regulating works:	
Earth, 1,100,000 cubic yards, at 40 cents	440, 000
Indurated clay, 480,000 cubic yards, at 70 cents	336, 000
Concrete in regulating work and for protection of diversion channel, 189,000 cubic yards, at \$8	1, 512, 000
Regulating gates and machinery complete	320, 000
Allowance for preparatory work at site of Gatun dam and miscellaneous expenses	200, 000
Total for Gatun dam	7, 788, 000

The following is the schedule of unit prices (Board report, pp. 419, 420):

Dredging:	Cubic yards.
Mud and sand in Colon and Panama harbors	0. 15
Soft material removed by hydraulic pumps in canal	. 25
Indurated and hard clay requiring cutters	. 70
Coral rock	1. 50
Rock drilled and blasted in the dry to elevation —25, removed by dredge	1. 50
Rock removed under water	2. 50
Dams:	
When placed in dam by pump from barges below elevation +50	. 20
When placed in dam by pump from barges above elevation +50	. 30

Now, the material in Limon Bay is very light and soft. A rail used for sounding penetrates many feet by its own weight. It is not proposed by the Commission to provide the breakwaters at present (see letter.) This means that the water of the bay will nearly always be too rough to permit the use of dipper or clam-shell dredges or suction dredges discharging into barges. It will require the employment of self-propelling, self-contained hopper dredges of large size and special design, fitted to discharge their silt cargoes ashore when the vessel has steamed to Gatun. But the minority has not figured on such craft here at all. The writer is operating half of all that exist in the world, at Galveston. The old canal does not, unless redredged at considerable expense, provide water for the large fleet of such boats necessary to dredge and transport, say, 5,770,000 cubic yards of material between mile 0 and Mindi mouth, and the price, 15 cents, is wholly inadequate for such a performance.

Again, the new line leaves the old canal just above Mindi mouth. It bears to the east and runs straight into the cluster of hard knobs and low hills of Mindi Gap. These introvertibly contain indurated clay and the hard clay rock which the French found there in making their Mindi excavation.

Senator MORGAN. Why did the French make that excavation there?

Mr. BATES. That was to get a straight alignment to Gatun, sir. It was simply a question of alignment and dodging the hills.

Senator MORGAN. It was out of the side of the hill?

Mr. BATES. Yes, sir. I will show you, Senator, the actual shape of the hill on these models later.

The new cutting of the minority is 500 feet wide on the bottom and 660 feet wide at the surface. One may see from the Maltby profile some of the hillocks rising to 50 feet above sea level. The cutting in places will be 810 feet wide. At the curve (mile 5½) it must be still greater, and the material must inevitably be largely refractory. Now, first, the top material, with roots and vegetation, will not deposit well or easily in barges if an attempt be made to load such by hydraulic dredges.

Second, hydraulic dredges with cutters can not excavate the Mindi rock clay at any price warranting the consideration of their use there. Much of this material will have to be drilled and blasted, or Lobnitzed, and the naïve proposition to dredge this refractory clay and rock by means of a suction dredge with cutters and put it into barges is, to one with first-hand experience in building and operating, simply preposterous.

Senator HOPKINS. How much of that has got to be blasted there?

Mr. BATES. Either blasted or Lobnitzed on that approach—possibly 4,000,000 yards.

Senator HOPKINS. What length?

Mr. BATES. It is about 3¼ or 4 miles.

Senator HOPKINS. It will have to be blasted for a distance of 4 miles?

Mr. BATES. No, sir; do not understand me that way, because the material varies. You run into a group or cluster of small hillocks that stick up from the surface of the morass, and there is where you find indurated clay.

Senator HOPKINS. How much of that 4 miles distance will, in your judgment, have to be blasted?

Mr. BATES. I should say at least half a mile would have to be blasted, and yet there are other methods for severing the material from its bed which may be employed without blasting.

Senator KITTREDGE. I understand that you cover all these questions in your statement?

Mr. BATES. Yes, sir; that is all covered in my statement a little later on.

Senator HOPKINS. It is a little more intelligible to me to get at it now.

Senator MORGAN. Has any great geologist ever attempted to account for those hillocks that appear in that morass?

Mr. BATES. I think a French geologist claimed that that Mindi Range was a later uplift. Whether it was or not I do not think anyone can tell or know.

Here is a sample of the clay rock from Mindi. Such material must be severed from its bed and put into barges by a dipper or, preferably, by a multiple-bucket dredge. Under such machines much of the stuff deposited into barges will be in large lumps, in sizes up to a cubic yard or more. The material is manifestly in no condition for being "pumped from the barges into the dam." It must be granulated first mechanically. To such service the cutters of a suction dredge at the dam stations are not suited. The writer knows of no way for effecting this save by cumbersome and untested process of stamping, crushing, or granulating.

Now, assuming even that this sequence of operations was actually effected (but, be it clearly understood, assuming it a moment for argument only) and that the stuff was mechanically prepared for the dam, we have to consider next where pumps are to be located, and, further, their relation to the work they have to do, viz, lifting this prepared material through heights of 50 and 80 feet, for the minority's Gatun dam is to be 135 feet high.

The macerating and pumping stations (in numbers, since 5,000,000 cubic yards are expected to be handled per annum) must be located below the center of the east and west sections of the dam. For the east section the old canal affords access; for the west section barges must come up to the junction of the old canal and the Chagres opposite Gatun, then go down the Chagres, then up the old west diversion a distance of 2 miles. This old bed and diversion would have to be made navigable at considerable expense, for they are not deep enough for the service demanded by the barges and tugs.

Next, we are met with the fact that nowhere ever yet has material been pumped to a distance of 2,000 feet and then lifted higher than 35 feet. Beyond that combined distance and lift everything is experiment. Theoretically, centrifugal pumps may be compounded or siamesed, but no one in the whole wide world has had the experience which would give any warrant for resting the execution and the estimates of time and money for this dam on the basis put forward by the minority and approved by the Commission.

Nowhere can a single instance be cited; nowhere can a satisfying demonstration be named. It is nothing short of monstrous to jauntily rest this national enterprise upon untried methods, vastly beyond the range of experience and past success.

In his testimony, the chief engineer (p. 900 of the investigation of Panama matters by the Senate Committee on Interoceanic Canals) supports this treatment. So much the worse.

The material dredged between Mindi and Gatun does not have to be taken "to the deep sea and dropped," as he declares. The marshes each side afford ample spoil areas. It is far more practical to haul Culobra material and build the dam in layers, thoroughly wet and rammed down, but this is another task. Spoil must then be rehandled from the trains and be lifted far above the present railway grade in the valley.

Assuming, however, next, that this structure, containing 21,200,000 cubic yards, were built, it would normally sustain the lake proposed. But it could not, of course, be earthquake proof, not fissure proof, nor subsidence proof.

Senator HOPKINS. There is nothing that could be earthquake proof, is there?

Mr. BATES. Oh, yes. In Japan they build a light wooden house instead of a huge masonry structure, and they prefer to live in safety in a little wooden house than in danger in a masonry structure. That is an earthquake country.

Senator MORGAN. They had an earthquake in 1888, of which a full statement from the daily papers is in the record of the former examination—a very fearful earthquake that extended clear over from Panama to Colon and tore the houses down, displaced steel railroad bridges, and then appeared near Bocas del Toro in little volcanic pits,

throwing hot water and steam. That was in 1888. Recently they had another one opposite the islands of Galapagos, just below that on the South American coast, that reached across the continent to Cartagena. We need not discount the earthquakes in this proposition at all.

Senator HOPKINS. I did not mean to interrupt Mr. Bates in his statement.

The CHAIRMAN. Proceed, Mr. Bates.

Mr. BATES. Against these risks the minority center the whole availability of the canal in this one feature. The waterway in any eventuality to the dam would be useless until it could be restored. But restoration would be a dredge, barge, and train work not of months, but of years. A crevasse must carry out millions of cubic yards and scour a chasm many scores of feet, under the portion carried away, and for a long distance downstream. Nothing could stop it. The refilling of the lake alone would require nearly a year. Further, the high level made by the dam is less convenient for ships than a lower level, because each must be lifted and lowered every transit through a total of 45 unnecessary feet.

Senator KNOX. Excuse me for interrupting, but it does not seem to me that this is the most profitable way of getting at your facts, Mr. Bates. How much of this matter is there to be read? We could only get a very superficial notion of it by having you read it, and if it is going to be printed it seems to me that if you have anything definite to say about your own plan as contradistinguished from the others it would be more illuminating to point it out on the maps and designs here, rather than merely to read what you have prepared.

Mr. BATES. If you would prefer, I will come right to that point now. In fact, I have reached the point where I think it would be pertinent to do that, Senator. I will, from now on, point out on these maps as I read. I have come to just the point where I should like to do that.

Senator DRYDEN. I should like to have Mr. Bates, in his remarks and procedure here, treat this matter, so far as I am concerned, at least, as if it were entirely new, for Mr. Bates's plan is new to me. I would like to have him take it up de novo, and so explain it that we who are not scientific men—at least I am not in this line—can have this matter put before us so that we can clearly understand his plans.

Senator KITTREDGE. As I understand, the purpose of Mr. Bates is first to criticise the plan of the minority, and I anticipate that he will later explain his plan and show why it is preferable.

Mr. BATES. Yes, sir.

Senator KNOX. My point is that the reading of something which we are to have in our hands later on, when we study this proposition, is a waste of time. If he gets up and shows us what is wrong with the minority and majority schemes and what is right about his, as contradistinguished from them, I think we would get some more intelligent impression about it.

Senator HOPKINS. I want to know if I understand the Senator from South Dakota correctly, that Mr. Bates comes here simply to criticise the minority plan?

Senator KITTREDGE. No; that was not my statement.

Senator HOPKINS. You said something that gave me that impression. That was the impression I received from the remark that you made.

Senator KITTREDGE. The substance of what I said was this, that thus far Mr. Bates has devoted himself to the criticism of the minority plan.

Senator HOPKINS. Yes.

Senator KITTREDGE. And I assumed that a little later he would state his own plan and compare the two.

Senator HOPKINS. Has he any views regarding the majority plan?

Mr. BATES. Yes, sir.

Senator HOPKINS. And was it his purpose to present views regarding that also?

Mr. BATES. Yes, sir.

The CHAIRMAN. I think it would be better if Mr. Bates were permitted to finish his statement first and then have the questions asked afterwards.

Senator HOPKINS. I want to get a little knowledge about this so as to follow it. Is this witness impartial between the majority and the minority—that is, to the extent that he condemns both?

The CHAIRMAN. I rather think that will be the result when he gets through. Then he will give his own plan, his own ideas as to the canal.

Senator TALIAFERRO. I think that the time has come for this committee to decide whether we are going to consider the plan submitted to us here or whether we are going to take up entirely new and different plans. If we are going to take up new plans for this canal it seems to me that we should make it known to the public, so that anyone who has a plan to submit may bring it here. If we are going to open this question up for new plans, instead of considering the matter that has been committed to us for consideration, it seems to me that it is only fair to all who may have plans for a canal that they should be given the opportunity of coming before the committee and submitting their plans.

Senator KNOX. That suggestion, I think, has a great deal of merit in it. It was the suggestion that I made the other day in opposition to calling Mr. Bates at this time. I thought that we had a specific work laid out for us, and that was to determine as between the reports of a great board of engineers, one a majority and one a minority report, which we would recommend—not for us to prepare a plan or to call in outsiders and to indorse an outside plan.

Senator HOPKINS. Was your plan submitted to this board of engineers, Mr. Bates?

Mr. BATES. Yes, sir.

Senator HOPKINS. The same one that you are elaborating now to us?

Mr. BATES. Yes, sir.

Senator TALIAFERRO. It was submitted to the board of engineers, as I understand, and condemned or rejected in detail.

Senator HOPKINS. Is that correct, Mr. Bates?

Mr. BATES. Yes, sir.

Senator KNOX. You would hardly expect us, Mr. Bates, a body of laymen, to take up a matter and decide it as between you and this board? Do you think we could do it intelligently?

Mr. BATES. Senator, all I should say is this: I think that by the time I have submitted what I have here—and I have only begun the real objections—that you will be very willing to consider something else besides the majority and minority plan, whether it be mine or any plan that anybody else can advance.

Senator MORGAN. Mr. Chairman, there is no doubt at all that the first duty of this committee is to determine between a sea level and a lock canal as to the general plan, and, after that, to take up the statements of experts in respect of the best type of canal to be executed on the plan we select. That, I think, is the proper course for the examination. In determining between a sea level and a lock canal we have before us a fully detailed exposition of the lock plan that was recommended by the minority of the Commission. I say recommended; I so understand it. They took that plan of a lock canal as a fair comparison, as I understand it, between the lock system and the sea-level system. They adopted that as a standard of comparison. But I do not understand that the report of the committee or the message of the President committed either of those functionaries to the adoption of the particular plan for a lock canal that was set out in the minority report.

Mr. Bates's testimony as far as he has gone is a criticism upon the plan that was used by the Commissioners and referred to the President and to the Isthmian Canal Commission for the sake of illustration, and probably with the expectation of its being finally adopted. I think that the criticisms he is making upon the lock plan as proposed are important, for the reason that it may turn out that that lock plan as inadmissible and can not be adopted; and while he is hammering down that plan, it may turn out that his plan will be hammered down by the same arguments. I do not know. But the inquiry as to the feasibility and practicability of the lock plan with a dam either at Mindi or at Gatun is a question that I think we are obliged to consider in determining the recommendation we will make as between the lock plan and the sea-level plan. That is my view of the present situation.

Whether we will go further and hear Mr. Bates explain his own plan is a matter that is within the discretion of the committee at the present time and at all times; but it seems to me, Mr. Bates having proceeded as far as he has, that it is proper to let him explain his plan throughout, particularly in regard to the dam at Gatun and the handling of the water at Gamboa, and also and perhaps more especially in regard to the Pacific terminus of the lock canal that he proposes, which is entirely different from that of anyone else that I have as yet heard speak upon the subject.

So I think, as we have proceeded with Mr. Bates's testimony as far as he has gone with it already, in justice to him we should let him complete his statement and then we will take into consideration whether we will have any more of the same kind of testimony.

Senator TALIAFERRO. I did not mean to make any objection to Mr. Bates concluding his statement. He has been invited here by the committee, and courtesy would require that we give him a hearing, after inviting him here; but I do think, instead of taking up our time listening to his reading of the statement, that it might go in the record, and he might explain by these maps or profiles he has here what his objections to the majority and minority plans are.

The CHAIRMAN. I think that is what Mr. Bates is trying to do, if we will let him proceed; but if it is desired that we take the matter up in a different way, it can be done at this time. Mr. Bates was certainly invited to come before the committee. The names were——

Senator KNOX. I think we all agree with Senator Taliaferro that we do not desire to shut Mr. Bates off. It is only a question as to the method that he shall employ in instructing us.

The CHAIRMAN. I take it that Mr. Bates desires, before he gets through, to give us his objections to the majority as well as the minority report. I think he wishes to criticise both.

Mr. BATES. Yes, sir.

Senator HOPKINS. I heartily approve of the suggestions of the Senators that the essay part of this statement be printed, where we can read that with the other matters, and that he give us the practical part, by taking his pointer and indicating on the profiles and maps here, taking up these different plans and suggesting and pointing out their defects.

Senator MORGAN. I have not discovered that Mr. Bates has indulged in any essay. I think he is making a very pointed statement of the engineering facts that bear very strongly upon this question.

Senator HOPKINS. Well, each Senator is responsible for his own understanding, of course.

The CHAIRMAN. Shall Mr. Bates proceed?

Senator MORGAN. I hope so.

Senator KITTREDGE. I agree with Senator Morgan. I would like to hear Mr. Bates.

The CHAIRMAN. Proceed, Mr. Bates.

Mr. BATES. It will be carefully noted that in the project B the writer has not undertaken to lift a cubic yard beyond the limits that have been actually and many times reached. When a Gatun dam is being built for his +62.5-foot summit level of B there will be a working level *made by Lake Chagres* at 33.5 feet, and there is, therefore, free and immediate access to every inch of this structure.

Further, the 35 feet of the extra height of 50 feet above the water line in the +85 Gatun dam does not add to water tightness. Instead, it does load the soft clay foundations and increases the danger of subsidence.

GATUN UNDER-SLUICE BARRAGE.

The minority, as well as the majority, at Gamboa and Corozal now adopt the under-sluice barrage to control the level of their +85-foot lake, abandoning the over spillway of the former +85 Lake Bohio project from the Giganté. The chief engineer has discovered a new over spillway site, for which he disclaims credit, up the Trinidad Valley, where the hollow of a saddle is "27 feet" above the lake. The writer sees no advantage in considering and substituting this locality, remote from the dam, when the central island and the sag next the west abutment of the dam offer a near and convenient rock-bottom foundation, as the borings show. The writer welcomes this tribute, though unavowed, to his insistent advocacy that the central principle of the Assouan dam be applied to isthmian conditions. He merely takes occasion to point out that under-sluice structures for an 85-foot head are larger and more expensive than for his similar works

of about one-third the head. The proposals of the writer are more safe, because the head is lower and they effect the same result.

MINORITY'S GATUN LOCK FLIGHT.

The minority's dangerously conjoined three Gatun locks are stated to have usable lengths of 900 feet. These lock lengths are 790, 790, and 820 feet on the official plans they have themselves put out, and which are indorsed by the Commission and the Secretary of War.

Here is a relief which I have had made of the Gatun dam and the lock site as it actually exists, to natural scale. This is the flight of three locks. Here is the upper lake [indicating on map], and this is the dam. There is the west abutment, and here is the Gatun hill.

The upper approach wall will be either founded in soft alluvium or must go 140 to 170 feet below sea level for rock. These locks can never be enlarged, because there is no room for enlargement in the hill. A Cunarder 788 feet long is to-day in process of construction, and a 788-foot ship can not safely venture into a 790-foot lock.

Here is an actual model of the ship, and this is taken from the official map [indicating map]. And there you see your vessel just fills your lock. She has 2 feet clearance. There is the Cunarder in that lock. This is taken with the greatest possible accuracy from the official plans.

The locks of the 85-foot canal recommended by the minority are obsolete before they are begun.

After reviewing the situation in some detail (pp. 36 to 40) the majority adopt the following (p. 40):

"That the locks on a canal of any type should be of such usable dimensions as will afford a length of 1,000 feet, a breadth of 100 feet, and a depth of 40 feet. It is further considered that if the canal were formed with smaller dimensions than these experience would prove it to be regrettably deficient in capacity."

On page 13 of the Board report is the following:

"As a basis for all plans the Board resolved, by 11 affirmative and 2 negative votes, that locks should have as a minimum usable dimension a length of 1,000 feet, a width of 100 feet, and a depth of 40 feet. The two members voting in the negative were Messrs. Noble and Ripley."

Now let us see what the minority of five and the Commission indorsed. Their report reads (p. 81):

"We believe this allowance for reasonable anticipation excessive, and that locks 95 feet wide, with a usable length of 900 feet, will fully meet the requirements of the act for both commercial and war ships, and recommend the adoption of these dimensions."

Page 82 continues:

"If the locks should prove, after many years (*after many years*), to be too small, larger ones can be built when needed," etc.

The minority therefore announce locks 900 feet long and enlargeable when needed. Inspecting the official map put out by the minority, and scaling the contours and structures, it is noted that practically the best and only feasible location has been chosen.

Senator HOPKINS. There would be no trouble, would there, in the minority changing their plan to a thousand-foot lock?

Mr. BATES. Yes, sir; that is just what I am coming to. The axis of the lock can not be swung advantageously, nor moved to the west nor to the east. Why? Because you get into bad country.

Senator HOPKINS. At the bottom there there is a hill, is there not? Why can they not go that way?

Mr. BATES. Because then you come into such tremendously deep cuttings. The hill rises right up.

Senator TALIAFERRO. Not deeper than the cutting at Culebra?

Mr. BATES. No; it is not. That height right there is 150 feet. It is 135 feet right in here [indicating on map].

Senator KNOX. That relates to the width of the locks. How about the length? What is the difficulty about that?

Mr. BATES. Just one moment until I get those profiles before you, Senator.

Senator KNOX. If you treat of it later on, do not stop now. I withdraw the question for the time being.

Mr. BATES. I do; yes, sir. I have brought the things that prove it.

So far so good. Next we measure what purports to be a 900-foot lock in the clear, and a flight of three locks 3,136 feet from end to end. We scale the plans and the locks and what do we find? Where are the 900 feet of minimum usable dimensions? The measurements give 790 feet in the clear—some 50 feet longer only than the discarded plans of 1901. Where are the locks of the minority, which wrote, "They will fully meet the requirements of the act for both commercial and war ships?" But perhaps they can still be saved and enlarged. We seem to remember reading "If the locks should prove, after many years, to be too small, larger ones can be built when needed." They are sorely needed. Can they be built?

Senator DRYDEN. Do you mean to say that the report of the Commission is false in that respect?

Mr. BATES. I say that their location and the official plan to which they have subscribed shows locks that are but 790 feet in usable dimensions.

Senator DRYDEN. While they claim them to be 900 feet?

Mr. BATES. They have not shown it, sir.

Senator KITTREDGE. The question was: "They claimed them to be 900 feet?"

Mr. BATES. Yes, sir; they claim them to be 900 feet.

Senator MORGAN. While those profiles are being examined I will ask you about your statement that the Commission begins with locks that are already obsolete. Do you mean in reference to ships that are projected in Great Britain or ships that exist in America?

Mr. BATES. They are obsolete with reference to the law which requires that there should be a full anticipation of the needs of the future. We already have a ship within 2 feet of as long as that lock.

Senator HOPKINS. It is a 790-foot lock, is it?

Mr. BATES. Yes, sir.

Senator HOPKINS. There is a difference of fact, as I understand it, between you and the minority. The minority claims that those locks are 900 feet, and you say they are 700?

Mr. BATES. I say they show but a 790-foot lock.

Senator HOPKINS. And they say they show a 900-foot lock?

Mr. BATES. Yes, sir.

Senator HOPKINS. It is simply a question of fact between you and the minority, then?

Mr. BATES. It is a question as to whether they can get a 900-foot lock into that hill at all. That is the question.

Senator HOPKINS. They say they can, and you say they can not?

Mr. BATES. Yes, sir.

Senator HOPKINS. Then it comes back to the proposition that you disagree with them on a question of fact?

Mr. BATES. Yes, sir. Here, as you notice, is the approach to the lock [indicating on map]. There is the depth to the lock under this approach. From the top there to the rock line is 234 feet. There is a lock that is scaled absolutely from the official plan [indicating]. There is a real 900-foot lock [indicating]. Here is a 1,000-foot lock of the majority placed in the best position on the hill [indicating]. You see what happens. There is no foundation for it. There is room in Gatun Hill for one lock, and there is not room for three with proper rock foundations. That is the whole story.

Senator TALIAFERRO. The minority say here, Mr. Bates: "We believe this allowance (that is, of the majority) for reasonable anticipation excessive, and that locks 95 feet wide, with a usable length of 900 feet, will fully meet the requirements of the act for both commercial and war ships, and recommend the adoption of these dimensions." Further, they provide for ships nearly double the tonnage of the *Dakota* and *Minnesota*, or 25 per cent larger tonnage than the projected Cunarders.

Mr. BATES. Yes, sir. You can see, taking it on their official plan, that that is not true. Here is an actual size Cunarder [indicating model], and when I put it into the lock which they have made there is not room, as you see [showing by means of model]. You could not safely put the ship in there. So that that statement is untrue.

Senator HOPKINS. You put that in on your dimensions. You have made the lock 790 feet instead of 900 feet.

Mr. BATES. I have taken that lock from their official plan on the actual scale. If you will look at the plan you will find it is exactly the same. There is no difference. I think somebody has made a mistake.

Senator MORGAN. They probably adopt the American limits for the capacity of the canal instead of the universal limits. If they do, I am with them. [Laughter.]

Referring to the profile which is presented, the top figure is the lock flight as laid out and approved for the 85-foot plan by the minority and the Commission. The relation of this unexampled mass of concrete to the firm rock of the hill is shown. All the borings which they had to go on, or which are now in the Government possession at Washington, are presented to you. How many, think you, there are? Four—one, two, three, four—borings. *Four* on the hill and *one* in the *valley*. These are all. These constitute the explorations for foundations to this unprecedented and unparalleled flight of locks. But they are still enough, however, to show that there is not safe room in their hill for the 3,136-foot flight of short locks and the 1,200-foot approach piers at each end, which the minority have put on paper.

On this same profile there is shown a lock 900 feet in the clear (to use the nomenclature of the isthmian report of 1901) in the best

position practicable. Below it, again, is a lock really 1,000 feet in the clear.

Now, note where the rock lies under the upper approach pier (figs. 2, 3, and 4). This pier is the structure along and against which vessels weighing 40,000 tons are to moor and to lie. The top is, say, 9 feet above the lake, or at +94. It is 1,200 feet long, five times as long as the Trinity Building in New York, and nearly as high above the rock as its twenty-first story is above Broadway. At its outer end, where the contours show the water to be 80 to 85 feet, the distance from the base at the rock line to the top of this structure is 234 feet. What is to be said of such a plan? Will the minority put this concrete structure on soft clay, or build an array of Eiffel towers? Besides, if the proper distance is to be maintained between an entering and a departing ship, there should be *two side approach walls*, not merely *one central wall*.

Figure V shows another position with 1,000-foot locks. Under the outer end of the upper pier the rock is 264 feet below its top. In position IV, the lock entrance of the minority, at the bottom is 20 feet above the rock, and the mass of entrance masonry, which contains the "safety" gates, must be 45 feet high above the rock and supported by "back fill." At the other end the next set of gates is incased in concrete 46 feet high above the rock. With the central lock it is about the same.

It is therefore revealed that there is safe room in Gatun Hill for one lock and its approach piers, the latter to be founded on rock within feasible foundation depth. But there is not room for a flight of *three locks* large enough to comply with the law of Congress or even large enough to pass the new Cunarder of to-day.

If, then, there is not space in the hill for even three abridged locks, how are bigger ones to be installed?

The drawing shows a Cunarder in a lock of the minority's dimensions. There is no margin. The letter of the Commission says (p. 17):

"The minority point out that the dimension proposed by them will provide for ships having 25 per cent more tonnage than the new Cunarders. If ships too large for these locks should hereafter be developed, it will be possible to add new and larger locks to accommodate them."

Was the writer disclosing a fact when he said the minority's lock, and hence the minority's canal, as officially presented and indorsed, is obsolete before it is begun?

DISADVANTAGES OF LOCKS IN FLIGHT.

It is not practicable to use a divided lock when two or more are conjoined. This the minority concede.

You see a vessel entering a lock leans its shoulder, so to say, against this approach. If, coming out of the lock, she comes against this central pier, a vessel entering and a vessel departing of this great size are in too dangerous proximity. Therefore I say that there should be side approaches instead of relying on one central one there, in order to reduce the total amount of concrete in that position. My contention is that there is not room enough in Gatun Hill nor either side of where they put their locks to put in a flight of three

locks even of the size of the one they have projected—790 feet long—much less one 1,000 feet long, and that they can never enlarge it.

Senator TALIAFERRO. I do not see why they can not extend the length of those locks. You have not made that clear at all to me.

Mr. BATES. Just look at the profile there.

Senator TALIAFERRO. Point it out on the map with your stick.

Mr. BATES. That is not a profile, sir. This is a profile [indicating]. That is a plan of the lock, and this is an elevation. That is the boring point there. There is another one there, and there is one there and one here [indicating]. Those are all the borings on that site. Then we have one more showing that the Gatun gorge, the deep trough, passes under the end of the approach pier. That is what makes it so deep down to the rock.

You see that position there in the hill that the lock is right close to the brow of the hill there, which is as near as it can be put with safety. I tried putting it nearer in this plan here, and you can see what happened. If you will look closely at this model, you will see a 1,000-foot lock superimposed directly over it. See how much longer it stretches. There is the end of the lock here and there is the end there [indicating on map]. If you lengthen your lock, you move the position of the upper gate toward the brow of the hill and the approach wall is put out so far, and the distance from the bottom of the canal to the rock below becomes so great that, so to say, your whole lock structure is on stilts.

Senator TALIAFERRO. Why can you not go on down to the rock bottom?

Mr. BATES. If you want to go down with unlimited money.

Senator TALIAFERRO. It is not a question of cost, but of safety.

Senator HOPKINS. Your objection is not that there can not be a three-lock system, but that it is going to be expensive, then?

Mr. BATES. It is going to be expensive and absolutely hazardous; and not only is that true, but—

Senator HOPKINS. How can it be hazardous if you can get to a rock bottom?

Mr. BATES. Can you get to a rock bottom there, at 140 feet—

Senator HOPKINS. That is for you to say.

Mr. BATES. I say no.

Senator HOPKINS. How deep would you go down there?

Mr. BATES. I would go with but one lock. That is in the project—

Senator HOPKINS. Yes; I withdraw that question. You are now criticising the three-lock system of the minority?

Mr. BATES. Yes, sir.

Senator HOPKINS. Does their system of locks extend out into the bay there as you have pointed out on your map?

Mr. BATES. Precisely. That is directly from the official plan.

Senator HOPKINS. Yes. How far out into the bay does it go on that projection?

Mr. BATES. That projection, from there to there [indicating], is 1,200 feet.

Senator TALIAFERRO. So that you withdraw your statement, or modify your statement, Mr. Bates, that those locks can not be lengthened in that position, and substitute for it the statement that they can not be lengthened without great cost?

Mr. BATES. Not without very great cost and without very great increase of hazard.

Senator HOPKINS. What do you mean by "hazard?" Hazard in what way?

Mr. BATES. The hazard relates to having your foundations at great depth and the great difficulty of reaching those foundations.

Senator HOPKINS. As an engineer you concede that it can be done, do you not?

Mr. BATES. I concede that you can remove mountains if you have money enough.

Senator HOPKINS. We are not talking about mountains now, but we are going the other way. You concede that they can go down 140 feet to rock?

Mr. BATES. No, sir.

Senator HOPKINS. Then you deny that they can do that?

Mr. BATES. Yes, sir; satisfactorily, with a concrete structure of that weight and height. It is below the limits of possible pneumatic work. The best that has been done so far is about 90 feet.

Senator TALIAFERRO. Then you adhere to your proposition that it is impossible?

Mr. BATES. Yes, sir.

Senator KITTREDGE. Will it interrupt you if I ask you a question?

Mr. BATES. No, sir.

Senator KITTREDGE. In regard to these foundations. Have you read the testimony of Mr. Stevens, the chief engineer?

Mr. BATES. Yes, sir.

Senator KITTREDGE. Do you remember his statement in regard to the foundation of the locks proposed by the minority and him?

Mr. BATES. I do not recall the statement; no, sir. You mean as to where he would locate his locks?

Senator KITTREDGE. No; where the foundation of the locks would be.

Mr. BATES. No, sir; I do not recall it.

Senator KITTREDGE. I will look it up in Mr. Stevens's testimony. You need not stop on my account. I will look it up while you are speaking.

Mr. BATES. My position in regard to locks at Gatun and their practicability is that there is ample and safe room, on easily reached rock foundations, for one long lock and its approaches, and that there is not room for these three short locks and no room for further enlargement.

Senator HOPKINS. Did you point that out to the engineers in presenting your plan?

Mr. BATES. No one ever dreamed of a three-lock flight at Gatun when that plan went in.

Senator HOPKINS. When your plan went in?

Mr. BATES. Yes, sir; here is another point I want to mention: The disadvantages of locks in flight. It is not practicable to use a divided lock when two or more are conjoined. By divided locks we mean a long lock with an intermediate gate.

Senator HOPKINS. What do you mean by an intermediate gate?

Mr. BATES. If you have a lock a thousand feet long, you put an intermediate gate, so that you can either lock a vessel 400 feet long or one 550 long. That is the point.

Senator HOPKINS. They do have such, do they not?

Mr. BATES. Oh, yes. They have been provided in all the single locks that have ever been considered for Nicaragua and Panama.

Senator KITTREDGE. I have found what I had in mind in Mr. Stevens's testimony. Will it interrupt you if I read it here?

Mr. BATES. Not at all.

Senator KITTREDGE. I read from page 978 of the testimony of Mr. Stevens, chief engineer:

"Senator GORMAN. Under that plan (referring to the lock plan of the minority) the foundation of your lower lock must be, of course, below the sea-level part of your canal?

"Mr. STEVENS. Yes, sir.

"Senator GORMAN. What sort of a foundation can you get for this immense structure?

"Mr. STEVENS. Clay.

"Senator GORMAN. You would trust that lock on a clay foundation, would you?

"Mr. STEVENS. Yes, sir."

Mr. BATES. Well, I will explain. Here is a sample of the clay that he had in mind. [Exhibiting sample of indurated clay.] It is a very great misnomer to call this clay. We lack a name. I got that boring when I was at the Isthmus, and that is the indurated clay rock. When you taste it, you get the characteristic taste of clay; but it is exceedingly hard and dense, and forms a splendid foundation; and that is the clay rock all through Gatun Hill. It is when you reach this stuff that you have got something which he calls clay.

Senator DRYDEN. Do you agree that that would be a sufficient foundation?

Mr. BATES. Oh, splendid; nothing better.

Senator KITTREDGE. You say that that is the clay that Mr. Stevens refers to?

Mr. BATES. Precisely.

Senator KITTREDGE. And at what depth do they go to reach that?

Mr. BATES. In these borings on the Gatun Hill, right on the verge of the hill, you see [indicating on map], we find it at about 20 feet. Then it drops off immediately into the Gatun Gorge, which is 208 feet deep on the side and 258 feet deep on the other, as shown by your profiles.

Now, then, this submerged gorge—there is the island right in the center here [indicating on map]—has one path leading right across this way and another one leading in that direction, and this approach pier comes over the gorge, and the brink of the hill is right on the edge of it. Then the rock line runs from 20 to 30 feet under the surface down the hill and goes under the morass, and all the way to Mindi, so that your upper 20 feet between Gatun and Mindi is soft and easily dredgable material; and as soon as you get into indurated clay of this character you have to use a different kind of plant from what you would use on the upper material.

I was just about to speak about the disadvantages of a flight of three locks when two or more are conjoined.

Vessels seeking transit will range from the little coasting steamer to a 1,000-foot liner. In the lock plans of the minority the whole of each lock must be used at each passage. This is a great waste of lockage water, which in the future may prove serious. It takes

more than double the amount to pass 50,000,000 tons of shipping if the locks are separated and the divided-lock principle can be employed. This is because 85 per cent or more of the steamers can pass, by using one of the sections into which the long, single locks, proposed by the writer, are divided. Thus it comes that the tonnage capacity of the Bates projects A and B is *double* that of the +85 with the same expenditure of water, under ordinary conditions of dispatching vessels across the Isthmus. The minority's and the Commission's +85 plan, therefore, is most decidedly inferior, and, for the future, menacingly inadequate. The Board, in selecting their +60-lock plan, put a lock at Bohio, and thus threw away, because they had not considered the Mindi lock site, 43 per cent of the lockage water which the rainfall of the region supplies.

Here is the situation: In order to have the greatest capacity for the lock canal at the Isthmus you have got only all the water that falls on the Isthmus and no more. From Bohio down no more lockage water would be available than that which fell on the watershed above Bohio. If you put your lock at Gatun, you get practically all the water on the Isthmus, except from a little watershed of the Mindi. Consequently it is bad to limit the lockage water supply on the Isthmus.

There can not be any more natural lockage water than the clouds give. This is distinctly limited, as the records reveal.

Furthermore, if the locks are separated and are themselves each divided, it becomes possible to use the lock either in *full* lifts for the extra long ships or in *half* lifts for 85 per cent of the commerce. When the *half* lift principle is utilized but half as much water is used up; and here again the divided and separated locks of the projects of the speaker can pass double the tonnage of the +85 scheme, and are by so much more decidedly superior to all the others. It is a sure conclusion that the divided and separated lock system of "B" gives *four times* the ultimate canal capacity of the +85 project.

I never would put but one lock in a location. I believe a flight of locks of two or three is dangerous. It is all right for small canal boats, but when you are dealing with masses of thirty or forty thousand tons' weight you must have room to stop the ship. You have only to go up on the Hudson River, at one of the piers there, and see a big ship coming in, to realize the force of the momentum of one of those large vessels.

The speaker's divided lock has, besides the ordinary safety gates and provisions for cutting off flow, a gate intermediate in the lock chamber, dividing it into usable sections, say about 425 and 550 feet long. Thus it comes that the intermediate gate is a *real* safety gate. When one considers the momentum of a great 40,000-ton ship, the safety gates of the minority are too close together (only 80 feet apart). Time and distance are required to stop such vessels. Consequently the divided lock is the real way of security from over-running.

In safety the locks planned by the writer are decidedly best and are free from the certain hazards which attach to the flight of three *abridged locks* on Gatun Hill, each already too small to pass a "new Cunarder" safely (much less the vessel "25 per cent larger"), which the minority submit and the Commission indorse.

Senator KNOX. Would it be contemplated to move these great vessels by their own power in that restricted space, or would they be moved by some other power—by tugs or some other appliance?

Mr. BATES. They could not be moved by tugs. They would be moved in part by their own power and in part probably by winches. Senator TALIAFERRO. Steam winches?

Mr. BATES. Yes.

I am going to speak of the lower diversion channels of the sea-level scheme.

LOWER DIVERSION CHANNELS OF SEA LEVEL.

The majority's proposal includes diversion channels below Gatun on both sides of the canal.

Gatun-Manzanillo Bay division.—This artificial river is destined to carry the low-water and high-water flow of the watersheds of the Mindi and Chagres on the east side below Bohio. The area of the east and west drainage basins is not definitely known, but it is estimated at 500 square miles. The mean annual rainfall is 137.67 inches, with a recorded maximum of 205.61 at Bohio in 1898.

From this it follows that the mean run-off is approximately 3,694 cubic feet per second, or 77 per cent of the recorded flow past Bohio. For such a rainfall as occasioned the floods of 1879, 1885, 1888, and 1893 no observations or records exist to establish the volume contributed to the Chagres from its watershed below Bohio. Having regard to the known higher rainfall of this area, it seems eminently safest to reckon the contribution to be 77 per cent of the 140,000 cubic foot-seconds maximum conceded to have passed Bohio in 1879, or 100,100 cubic foot-seconds.

The streams from the east—the Gatun, etc.—are nearly the size of those from the west—the Trinidad, etc. The mountain source, back of Porto Bello, is higher. Therefore we may take it that at least half, or 50,000 cubic foot-seconds, may in emergency come from the east and 50,000 cubic foot-seconds from the west.

That the flow in this diversion shall not exceed 6 feet per second, above which velocity the diversion banks will seriously erode, the diversion must have an area of $\frac{60000}{7} = 8,333$ square feet. But this equals a channel as large as the canal itself. If it be 20 feet deep, it must be 417 feet in average width.

Technically such volumes mean, with the small diversion channel proposed by the Board, either—

1. The velocity of the escaping flood must seriously and irregularly erode and damage the banks of the diversion and the septum separating these rapid flowing waters from the navigated channel, or

2. The impounding of a large lake in the lower valley of the Gatuncillo higher than the channel between Gatun and Bohio. This lake would be separated from the canal channel by a narrow levee 8 miles long, liable to crevasses from overtopping, to subsidence into the swamp mud, or to perforation by animals.

Senator KITTREDGE. You mean the channel of the canal?

Mr. BATES. Yes, sir. It either must escape past Gatun through the channel or it will pile up and come against the levees separating the canal from the low area.

The only relief from this condition must be found in a larger diversion or in a very long under-sluice dam connecting the Gatun spur and the Tiger-Lion group of hills, thus creating another lake basin from which water could be suffered to pass out gradually.

The meager data quoted on page 186 of the report regarding the flood records to 1889 for the Gatuncillo and Trinidad rivers apparently fall far short of an 1879 maximum.

On the west side, while the old Chagres bed affords a large enough way for the overflow of the high permanent lakes filling the valleys of the Cano, Giganté, and other streams, and the floods of the Trinidad, the western diversions should have a large cross section to assure a proper factor of safety. Hence it follows that the majority provisions—technical, financial, and for maintenance—for this 14½ miles of eastern diversion are wholly inadequate.

It would take a canal passing Gatun 20 feet deep and 417 feet wide, or a channel equal in area to that of the main canal itself, to carry off the flood water coming from the Gatuncillo watershed in the case of such a flood as that of 1879.

The writer subscribes to the view that the Commission in adding but \$6,500,000 to the sea-level estimate was very conservative.

MINDI GAP AND RANGE AND CHAGRES RIVER BELOW GATUN.

The advisory report refers in these terms to these first vital land features encountered beyond Limon Bay (pp. 25 and 26) :

"It early became apparent that additional information was desirable relating particularly to the possible dam and lock sites at Mindi, Gatun, and in the vicinity of La Boca. The Board requested the Isthmian Canal Commission to have further examinations made, as follows:

"1. On the Mindi line the examination to be topographic with respect to the ridge line to the east of the Mindi through to Jaramillo Hill, thence to the shores of Limon Bay, in order to develop any low passes communicating with the Chagres River, and over the Jaramillo Hill near the high ridge line to the Chagres River and across the same, connecting with the high land to the west of the Chagres. This examination to be carried up to elevation 50."

With reference to the Mindi location, Mr. F. B. Maltby, division engineer, reported:

"On the west side of the canal the high ground is continuous from the Jaramillo Hill to the Chagres River. * * * From a personal examination I am quite sure that a point can be found in this vicinity where the distance across the Chagres Valley to an elevation of at least 50 feet is not more than 3,000 feet."

You observe that the Chagres, after passing Gatun, runs in a narrow valley with numerous spurs running down from either side. Neither the French nor any American commission has ever made a survey or boring in there. I have had it examined myself.

"I think it more than probable that surveys would develop a possible crossing of a shorter length. On the east side of the diversion at Mindi the hills are simply isolated knolls for a distance of half a mile east from the diversion channel. From these there is a continuous ridge which is very much broken in elevation, but in which

there is no point which has an elevation of less than about 40 feet." * * *

You have this hill here [indicating on map], and between this hill and Mindi is a succession of nine knolls rising to a height of 50 feet; and they are from 100 to 200 feet apart.

"It therefore seems possible that should such a project be contemplated, a dam might be built from the Jaramillo Hills across the canal, connecting the various hills as far as the east diversion opposite Mindi. From there, for a distance of half a mile, it is probable that a dam, having a base at an elevation of only 5 or 6 feet above the sea, would require construction for half the distance. In addition to this there would be a dam across the Chagres River of about 3,000 feet in length."

In the Maltby report the asterisks represent the following omitted sentences:

(1) "This is the first hill on the right that we saw when we went down the Chagres River."

(2) "I have not had the time to prepare any maps showing this work, and, in fact, after what we have done is plotted it will show very little on a map, as it is simply a single line run irregularly, keeping at all times on the high ground, where such ground existed."

There is also the following unpublished letter:

ISTHMIAN CANAL COMMISSION,
DEPARTMENT OF ENGINEERING AND CONSTRUCTION,
OFFICE OF DIVISION ENGINEER,
Cristobal, October 26, 1905.

Gen. GEORGE W. DAVIS,
Chairman Consulting Board of Engineers,
Washington, D. C.

SIR: I have the honor to inclose herewith blueprint of a map, scale 1:3,000, from the vicinity of Mindi River to Gatun.

This map shows the results of some recent investigations made concerning the possibilities of a dam at Mindi and a possible relocation of the Panama Railroad to mount the elevation which would be created by the construction of the Gatun dam.

There is also a profile showing the elevation of the ground along the line B or from the west side of the canal at Jaramillo Hill to continuous high ground on the east.

Also a profile along line A showing a possible relocation of the Panama Railroad.

As stated in my letter of October 21, the Jaramillo Hill is continuous to the Chagres Valley, and the crossing of the Chagres Valley proper can be had with a length of not over 3,000 feet.

Very respectfully,

F. B. MALTBY, *Division Engineer.*

Copy to chief engineer.

The report details, page 124:

"Thursday, October 5, the members of the Board took train at 8 a. m., proceeded to Mindi, where they disembarked and climbed the hills to the eastward of the canal overlooking the country, and examined possible sites for locks and dams; returned to the train and

proceeded to Gatun, where the hills in that vicinity were climbed and a view of the country obtained.

"Messrs. Davis, Abbot, and Quellennac, accompanied by General Ernst, went by train to Gatun, thence by launch to the mouth of the Chagres River, thence by sea to Limon Bay, skirting the west and south shores of the bay to the mouth of the Mindi; entering the same, proceeded through the canal to Gatun, and, returning over the same route, passed out again into the bay and returned to the ship.

"The weather during the first five days of the stay of the Board on the Isthmus was exceptionally pleasant, thus facilitating the excursions that have been recorded. On Monday it commenced to rain, and the rains continued remittingly, but in large volume, until the Board left the Isthmus on Wednesday evening. The Board thus had an opportunity to observe the country under favorable conditions and also when the flow of the rivers was very much increased by the heavy rainfall."

An engineer detailed to examine the Mindi site for a terminal dam therefore reported its width less and its configuration far more favorable than even the previous data had shown.

The advisory board made the cursory examination which its report recounts. At its request Mr. Maltby was assigned to make a simple reconnoissance without borings east and west from Jaramillo Hill and across the Chagres. Those on the Mindi dam site eastward from Jaramillo Hill indicate that indurated clay rock is comparatively close to the surface all the short way across. There is no Bohio or Gatun geologic gorge at the Mindi Gap, and nothing to prevent a masonry-core dam or a perfectly tight rock-and-earth-fill dam here, or the rock-founded under-sluice barrage, as projected by the writer. He also found that to dike the Chagres and make the 35.5-foot lake there was needed a dike *only 3,000 feet long*.

That is the place where the French first encountered rock, and which sticks up 70 feet above the water. Numerous borings have been made across that site, so that we know practically that the clay rock is closer to the surface there at Mindi than at any other dam site on the whole Isthmus, except one on the Pacific side.

Across the Chagres Mr. Maltby finds the crossing from hill to hill at the +50-foot contour, but 3,000 feet *or less* most probably. At Gatun it is 1,675 feet more, or 4,675 feet between these same 50 foot contours. There are 4 miles of the Chagres below Gatun practically unexplored as to dam sites; places narrower than at Gatun between spurs of indurated clay rock. What right has anyone to conclude that because it is 258 feet to rock at Gatun it is the same or more in these 4 miles of river coursing among jumbled hills and spurs on either side, which may be, and probably is, a later uplift?

The water-borne deposit being lower down the river, must be more dense and less pervious, no matter how deep. Be it remembered that the dry dock at Colon, so much quoted for its demonstration of the impermeability of indurated clay, and Mindi and the Indio, are closer to the sea than Gatun. The utilization of the Mindi Gap and the Chagres crossing is the key to the best lock canal.

This record, meager as it is, is nevertheless more than appears anywhere in French or American canal official publications. The advising engineers are pioneers, albeit they did not stop and go ashore

anywhere and conducted their explorations at 8 miles an hour in a launch, in a blinding rainstorm.

On October 5 the distinguished party, which alighted from the train on the eastward side of Mindi Gap, and a poor place from which to observe "possible sites for locks and dams," saw but little more of the sites, which the writer brought forward, than if they had remained in Washington. The district is an uncleared jungle, where the actual configuration of the ground is not visible a dozen yards away. The great advantage of a lake above Mindi makes a consideration of this site of vital necessity.

Here is the situation: In order that there shall be sufficient lockage water for the future needs of a lock canal the waters of the Chagres and all its tributaries must be impounded in a lake created below where the rivers Trinidad and Gatuncillo come in. A dam at Bohio does not include these tributaries, and so can not give sufficient lockage. Hence the impounding summit level dam must be at or *below Gatun*. The only way to impound below Gatun is across the Mindi Gap and Chagres Gap. If a two-lock canal is to be built, and it is the one most easily transformable into a sea-level waterway, the Atlantic lock must be either at Mindi Gap and Chagres or Gatun.

If a four-lock canal is to be made and the locks not placed in flight one above another, a serious combination and one most to be avoided where great ships are concerned, the locks must be at Mindi and Gatun.

There is no escape from these conclusions and never has been.

Senator KITTREDGE. Why is it necessary to depart from the proposition of the minority in regard to their plan in that regard?

Mr. BATES. The reason is simply that they have their locks in flight.

Senator KITTREDGE. What harm is there in that?

Mr. BATES. Very serious dangers of overrunning; and the very fact that you can not use the intermediate gates. That is, when you put your locks in flight you immediately reduce your lockage water. The single lock at Mindi and at Gatun gives the highest possible lockage capacity; and you limit your lockage capacity as soon as you put locks in flight, because you can not lock your small ships without using the whole lock, and consequently using up water. If you put in a torpedo boat you use more water than for a 1,000-foot ship where you have locks in flight. If they are not in flight, if they are separate and divided with an intermediate gate, then you can lock your small boat in half your lock, or two-fifths of it, just as you make your proportion. So that there are chances of the economy of the water where you have a separate lock system which do not obtain where you have them conjoined. So that the scheme of the minority with locks three in flight here [indicating on map] and two in flight at Sosa has about the least lockage capacity of any canal you could devise on the Isthmus.

Senator DRYDEN. Do you question the sufficiency of the water for this purpose?

Mr. BATES. Yes, sir—that is, I question the sufficiency of the water when you come to very large tonnage in the far future time. I think that for the first ten or twenty years, as I have shown in this book of mine, you will have ample water; but when you have a lock canal, you are committed to a lock canal. There is only one canal that can be transformed at any reasonable expense, and that is a two-lock

canal. If you have what is shown on this one here, a lock at Mindi and one where the majority has put it at Sosa, then you have, we will say, a lock canal at an elevation of plus 30 or 35 above sea level, one summit from lock to lock, and that is 40 feet deep. Then you are within the dredging limit. You can dredge to a depth of from 70 to 75 feet; they are doing that in the California mines now. That is the maximum dredging depth that I know anything about; so that it would be entirely feasible to transform a two-lock canal, but it is not feasible to transform, except at a very prohibitory expense, a canal with more than two locks. The water will get so deep in the lake that you can not dredge it.

Senator KITTREDGE. By a two-lock canal, do you mean a lock at either end?

Mr. BATES. Just a lock at either end. I made two projects—one of them with a lock at either end, making simply the end lakes, and another with four locks, putting one of them at Gatun and the other at Pedro Miguel. The reason for that is very simple. I can illustrate it by using the fingers of one hand [illustrating]. Your isthmus has four longitudinal ridges and consequently three valleys. If you turn to the old reports and all previous plans, you will see that they had a central lake at Bohio and a sea level. There are only four things you can do, and every scheme has to be some modification of those four things: (1) A sea level, cutting through all four of the ridges; (2) a center lake scheme, with sea-level ends; (3) a scheme with the two end valley lakes, or (4) the combination of the two end lakes and the central lake.

Senator TALIAFERRO. Why not go down from the Atlantic and have a sea-level canal on this side up to one side of the mountain, and up to that point [indicating on map], and from the foot of the mountain in the Culebra cut a sea-level canal to the Pacific?

Mr. BATES. Then you would have a lake in the center.

Senator TALIAFERRO. No; no lake.

Mr. BATES. Then you would have a sea-level canal all the way?

Senator TALIAFERRO. No.

Mr. BATES. Oh, this lake in there [indicating on map]? Yes, sir; that is a sea level all the way.

The plans I have just mentioned are the only four that can be suggested. Every other plan is some modification of one of those four plans. Before this time all the schemes of the French and of the Isthmian Commission that have been considered have had simply the central lake scheme. This scheme of the minority is the very first one in which an end-lake scheme appears.

Senator KITTREDGE. What did you characterize it? What sort of a lake?

Mr. BATES. An end lake; because they are at the two ends.

Senator MORGAN. Your plan contains four dams, if I understand it—one at Mindi, one at Bohio, one at Gamboa, and one at Miraflores. Is that correct?

Mr. BATES. No, sir; on the Panama side there is one dam at La Boca and a lock at Sosa Hill that creates a lake that I call Lake Panama. At this point, Pedro Miguel, is a lock and undersluice dam. At Gatun there is a dam; at Mindi there is a dam. That makes four dams across the Isthmus.

Senator HOPKINS. Whose plan is that—the four dams?

Mr. BATES. That is mine. The aggregate length of the two dams at Mindi and Chagres is not as great as that at Gatun. Then, a dam at Gatun. The level of this lake, from here to there [indicating on map], will be, say, plus 30 to 33. The level at Gatun is plus 62 above sea level. So that on none of the dams do I have a head of over 30 to 32 feet.

Senator MORGAN. You have no dam at Bohio at all?

Mr. BATES. No, sir; because I think that in putting a dam at Bohio you limit the lockage supply, so that I should utterly abandon that site. That is reason enough.

Senator HOPKINS. Have you investigated it enough to know whether there would be any difficulty in making a dam at Bohio?

Mr. BATES. I think you can make a Morrison type of dam—that is, combined earth-filled and rock-filled dam—at Bohio.

Senator HOPKINS. So that it would be all right?

Mr. BATES. Yes; you can build a Morrison type of dam at Mindi here, and at Gatun, and at Bohio, and over here—anywhere.

Senator KITTREDGE. Mr. Bates, why not put a double lock at Gatun instead of one at Mindi and one at Gatun, as you propose?

Mr. BATES. The objection I would have to that is this—there are two or three: In the first place I would like to make a combined salt and fresh water harbor. In the next place I do not want to put on any earth and rock fill dam on the Isthmus a head of over 35 feet.

Senator KITTREDGE. Why?

Mr. BATES. Because I think that it is not safe.

Senator KITTREDGE. In what respect?

Mr. BATES. If it should be shattered by an earthquake, for instance, you can repair a dam whose head is only 33' or 34 or 35 feet, because you can put material into that dam by mechanical means, but just as soon as you have increased the lift from that surface of the water on the dredge over 35 feet you have got into the realm of experiment where nobody has ever gone. I do not believe in making experiments, sir.

Senator KITTREDGE. You say "in the realm of experiment?"

Mr. BATES. Yes, sir.

Senator KITTREDGE. Do you mean that there are no locks with a lift aggregating 60 feet?

Mr. BATES. No; I do not know of any with that lift; but on the other hand, whenever you make a single lock that would lift as much as 60 feet you use an extraordinary quantity of lockage water. For instance, one of the early projects down at Panama was to have a lock at Bohio 100 feet high in one single lift. It was utterly given up because they recognized that every time you locked a vessel that only drew 24 or 25 feet you would be using up 75 feet of water under that ship.

It passes understanding, therefore, why this board and this Commission, like every one of their predecessors, have failed to grasp and act officially upon the supreme importance of *knowing* all there is to know of these localities and of any other possibilities that may exist yet undiscovered for shortening the canal or reducing its curvature in the narrow ridge from Jaramillo Hill westward.

There remains not one particle of doubt that by means of short, low, safe Mindi and Chagres dams, identical in their principles of construction with those advocated by Mr. Morrison and by the minority

and by the writer, a lake can be made with an elevation up to +33.5 feet, and possibly higher, below Gatun. And also there is no question that the foundations will be better than at either Gatun or Bohio.

With this conceded, Jaramillo Hill, the site of Balboa, becomes beyond dispute the best and only Atlantic terminus, which should be deemed permanent. It is surrounded by the fresh and salt water harbors, and its selection gives the *shortest canal course* between the two ocean dispatching stations *by 5 good miles*, over both the majority and minority Colon-saving schemes.

Colon is useful during construction; no longer; and Balboa will be a city wholly of these United States; not like Colon, located on foreign soil.

The writer concludes that up to Gatun there can be few dissidents to the adequacy of, and a preference for, his terminal city, dam and lock sites, and for the terminal lake and the naval station. It is certain that his contract estimates are fairer and safer than those of the Board or its minority.

GAMBOA DAM.

We have been brought by this comparative analysis and criticism to the high lakes, which the majority propose to create in the Valleys of the Cano and Giganté. One must yield the palm of originality to this engineering feature, which is to be found, the writer believes, nowhere before in the troubled annals of the canal's engineering history, for disposing of floods in the western watershed of the Chagres.

Two superfluous dams with the perpetual menace inherent in great permanent heads conceived to make lakes overflow their margins at spots never visited and never even surveyed. The idea is scintillant. It is a transference to new pastures of the old eastern impounding scheme of the last engineering committee with its great tunnel subway.

This heralded tunnel (smiled, be it noted now, out of court) gives place to an undersluice dam at Gamboa, much huger than the writer's, but of the Assouan type. (Vide remarks of the chairman on the occasion when the Board divided 8 to 5 on the type.)

"They (the floods) no longer menace anything or anybody, but the water serves a beneficial purpose by its distribution over agricultural land. One of the largest rivers in the world, the Nile, having a measured flood discharge many times greater than the gauged or estimated flow of the Chagres, has come under the complete control of men by works that were easily accomplished in less time than the engineers estimated.

"I have the feeling that the Chagres control will be easily attained in the sense we use the words respecting the attainment of large things, and that difficulty, to my mind, is of less and less importance as we better understand the conditions. A few years ago we knew little about it, but now the physics and hydraulics of this stream are probably as well known as those of any river in the world, and we can measure the due proportion and outlay for works for its control. It may, perhaps, cost as much as it did to make the dam at Assouan, on the Nile."

This has a familiar note. We quote from page 71 of the Bates presentation to the Board introducing the Assouan type of dam:

"In projecting dams of this type at Cano, Alhajuela, and Gamboa, as well as at Mindi and Sosa Barrages, cognizance is taken of this inspiring mile-and-a-quarter-wide demonstration that a continental river may be valved as a water pipe and may as perfectly perform its allotted task. The Assouan dam, however, had as its function to impound a large volume of clear Nile water and to let it out gradually during the irrigation season, after allowing the early silt-bearing floods to pass.

"The reversal of this duty is proposed by the author for the Panama sluice dams. What is here required is to catch and hold the high floods and, by maneuvering the sluices, let them run off gradually and harmlessly."

Also from page 93, Bates Report:

"By electrically manipulating their sluices the levels of Lakes Chagres and Panama can be raised and lowered. They can be reduced to a sea level or even below."

The volume per linear foot of such a dam at Gamboa varies approximately as the square of the head plus 45, the distance from the high-water mark to the rock line.

Hence we have—

Gamboa sea-level dam $(170)^2=28,900$.
 Gamboa Bates dam $(109)^2=11,881$.
 Alhajuela Bates dam $(109)^2=11,881$.
 Cano Bates dam $(109)^2=11,881$.

But the three smaller dams are besides each much shorter than the high dam. It follows that the Gamboa, Alhajuela, and Cano dams of Project B, taken all together do not equal the monumental volume of the vast concrete structure proposed by the majority.

The writer deprecates dependence upon the integrity of one unit and believes that the world's experience in distributing risks over several units is profoundly wise.

EARTH AND ROCK FILL DAMS.

For purposes of comparison the following table is inserted:

Approximate comparative lengths and volumes of earth dams.

	Project B.			Minority +85.		
	Cubic yards.	Length.	Head.	Cubic yards.	Length.	Head.
		<i>Fect.</i>			<i>Fect.</i>	
Mindi.....	1,500,000	3,800	33.5			
Chagres.....	3,000,000	3,000	33.5			
Gatun.....	4,635,000	5,600	29.0	21,200,000	7,700	85
Pedro Miguel.....				1,100,000	2,000	30
La Boca.....	1,300,000	4,200	26.5	6,300,000	4,800	55
			36.5			
Ancon-Sosa.....					1,750	65
						55
Ancon-Coroza.....				5,980,000	5,600	65
						55
Total.....	10,435,000	16,600		34,580,000	21,850	

The sea level has over 60 miles of levees separating the canal from the diversions. Besides these continuous levees the scheme embraces high dams of *quite unknown and unmeasured lengths*, impounding great permanent lakes, in the valleys of the Cano and Gigante. The sea-level diversions are all exposed to erosion. Thus it appears that the 85 has one more earth dam than has "B." It has *four* dams with *several times* the net head and height. The minority dams are about 5,250 feet longer, and they total 24,145,000 cubic yards more than "B's." The minority use the same formula of design, but include at Gatun 35 feet additional height of debatable utility. Attention is invited to the graphic diagrams from Pl. VII of the Board's report disclosing comparative cross sections of the dams and their positions. No one can gainsay that the unit prices for building the small dams must be lower than for building the high ones. This is why the writer refuses utterly and emphatically to subscribe to a common scale of unit prices. A common scale is a sheer absurdity from an executive standpoint. But everyone seems to repeat this misleading error, and on this fallacious premise criticisms are based.

Means and methods of execution must and will differ with every plan. Prices will be very markedly determined by these means and methods.

ESTIMATES FOR SANITATION, ZONE, GOVERNMENT, ETC.

ESTIMATES.

Premise: Neither majority nor minority have included in the estimate for building the canal sanitation or Zone government. These items must be added therefore to their announced figures.

(Report of the Board of Consulting Engineers, p. 148:) "After considerable discussion of the estimates submitted in the report with reference to the 20 per cent allowed for contingencies, etc., Mr. Parsons moved a reconsideration of the following resolution, which was adopted during the twenty-fourth meeting:

"*Resolved*, That we add to the estimates based upon the unit prices the sum of 20 per cent for administration, engineering, sanitation, and contingencies, exclusive of interest during construction, expenses of the Zone government and collateral costs.

"The motion to reconsider the resolution was carried unanimously.

"Mr. Burr then moved to amend the resolution to make it read as follows:

"*Resolved*, That we add to the estimates based upon the unit prices the sum of 20 per cent for administration, engineering, and contingencies, exclusive of interest during the construction, sanitation, expenses of the Zone government, and collateral costs.

"The motion to amend was unanimously adopted.

"Sanitation, expenses of Zone government, and collateral costs. How much must be added?"

For the year 1905, with few or no men at work actually digging, and with less than half the force which will be apparently employed when excavation is really in progress, the above items were as follows:

Page 193, Annual Report Isthmian Commission, 1905: "\$828,102.63, exclusive of \$355,001.48, for the 'construction of waterworks, sewers, and roads,' and exclusive of this department's pro rata of

'material, supplies, and equipment and cost of purchase, handling and transportation'—say, \$100,000 per annum. It would seem that during construction (whatever betide the department afterwards) a 'sanitation and Zone government' estimate of \$1,000,000 per annum for a lake canal and \$1,250,000 for the sea level is conservative. There is, therefore, to be added to the minority's total for its 85 scheme, 'nine years at \$1,000,000, \$9,000,000;' and to the sea level, 'thirteen years at \$1,250,000, \$16,250,000.' This at least. These sums added to the official estimates make the tally:

85 (minority estimate)-----	\$148, 705, 200
Sea level (majority estimate of thirteen years' execution)-----	263, 271, 200
Sea level (Commission estimate of eighteen years' execution)---	295, 480, 418 "

The President's message, February 19, concludes (page iv, letters transmitting the Report of the Board of Consulting Engineers for the Panama Canal):

"The law now on our statute books seem to contemplate a lock canal. In my judgment, a lock canal, as herein recommended, is advisable. If the Congress directs that a sea-level canal be constructed, its direction will, of course, be carried out. Otherwise the canal will be built on substantially the plan for a lock canal outlined in the accompanying papers, such changes being made, of course, as may be found actually necessary, including possibly the change recommended by the Secretary of War as to the site of the dam on the Pacific side.

"THEODORE ROOSEVELT."

Since the minority's waterway, by its own tally, exceeds the amount appropriated by Congress for a canal, it can not be constructed except after further Congressional action. Further, it does not appear in the estimates of the Board or Commission what credit is to be deducted for the \$26,500,000 already expended or bespoke for "equipment and supplies." Since these figures are dated "February, 1906," a deliverance is in order from the Commission and Board that \$139,705,200 minus \$26,500,000 equals \$113,205,200 minus \$23,284,200 (20 per cent contingencies) equals \$89,921,000. This represents, then, the real remaining sum. Do these engineers seriously expect to themselves or by contract complete the work for this price? Even if the Government should turn over the whole thing free of cost, work done, material, and supplies to the aforesaid alleged value, how is \$89,921,000 going to be made to cover the construction of their Panama Canal? These facts and figures must be set nakedly and truthfully forth if there is not to be a sad awakening perilous for the whole enterprise. A contractor is not privileged to bid a unit or lump price for "contingencies." He stands or falls by something definite, without benefit of clergy, and has no feather bed of 20 per cent, which is the haven of uncertain engineering where money estimates contain no personal financial hazard.

EVOLUTION OF CANAL PLANS.

Before he outlines his next group of criticisms he must make some general statements. The struggles between the two extreme types—the sea level and the high level—for Panama began at that far day which gave them both birth—the Paris congress of 1879.

There gathered to this congress one of the largest bodies of technical and scientific men that the world has ever assembled. Delegates were sent from the civilized globe—98 men in all. There sat in those sessions Sir John Hawkshaw and Sir Charles Hartley; Derks, constructor of the Amsterdam Canal; Voisin Bey, constructor of the Suez Canal; Waldorf, of the Swiss canals, and scores of the most prominent engineers then living. Our own Menocal and Selfridge were there, the first the intensest advocate the lock canal has ever had. To the technical subcommittee were submitted, as the congress record shows, some fourteen projects.

Each of the rival groups analyzed, sifted, eliminated, and finally amalgamated from the elements of these fourteen. The canals they respectively recommended represented the very highest and best that these two parties could evolve out of all the elements and all the projects thus far devised. They were buckling for the first great encounter in this arena of 98 men, and they omitted nothing which could strengthen their hand. They incorporated all the forces which could give them the mastery. If any feature was declined by its own party it was, to the best belief of that group, this feature, as then evolved, was to the canal, then and there planned, not desirable.

The two types locked horns in the general session, and the sea level won out. It entered upon its day, but its rival was not dead. The sea level never attained a supremacy so safe that it could lift its foot off the neck of its lock competitor. Commission after commission made through the years a continuous judgment bar. The struggle went on, yet neither quite vanquished and killed the other. Through this fight of over a quarter of a century we must believe that each steadily kept its gaze alert for every leverage and for every vantage. It has drawn from every known old source and from every new source sustenance and alliance. It has gathered unto itself strength when and wheresoever it might. It could have no conceivable purpose in declining and defeating any idea which could enlarge its power and hasten its triumph. If an idea was declined it was because this idea as then conceived was not deemed a good one for the canal as then projected. Its advocates could gain nothing by weakening their own cause.

It is therefore rational and just to believe that at every step of this long way the different guardians of the two types incorporated at the various stages all that they knew and all that they believed best for their ward types. The quarter century has been for each a gradual evolution. Out of the struggle came the survival of the fittest, and what stood September 1, 1905, as types for the sea-level and high-lock canals represented the fruitage of all that had gone before. When the Panama came into the hands of our Commissioners, two years ago, they had the legacy of twenty-five years in engineering history. Still anew the elements were studied, analyzed, sifted, eliminated, and amalgamated. As recently as seven months before the international board convened a latest report was made reviewing the high level and the sea level up to date. The high level was left unchanged by the Commission, and virtually in its then existing form was submitted to the international board. The sea level, confirming a last departure, a tunnel (see Report, page 10),

submitted also its latest and, as we must think its official advocates believed, best evolution.

These two types, therefore, came September 1, 1905, to stand before the final technical bar for the death throw. Either they incorporated all the canal elements which their sponsors knew to be desirable—and these men were true to the canal's interest—or they did not incorporate all the elements which the men knew to be desirable, and they were not true to the canal's interests. The writer, in this hypothetical case of Commissioners, would choose for them the better part. He believes that all along this technical march each Commission and Commissioner contributed according to his truest light, and that when these two projects went, September 1, 1905, to the international board they expressed the best and highest that the various exponents at that time knew.

It becomes, in the face of this history, surely legitimate to inquire what were the elements, the features, the treatments of the two types as submitted to this body. In short, first, what were the canals as they went into the international board? Second, did the Bates project enter the board incorporating other features and treatments? Third, what were the canals as they came out from the board? The Sphinx at Panama has ever been the Chagres River.

The sea level of September 1 was characterized by certain features for Chagres control. It had a tunnel $3\frac{1}{2}$ miles long. The tunnel of De Lesseps's engineers had at last won out; it was recommended. It had diversions for 20 miles paralleling the canal. Through these diversions it carried the Chagres waters to one ocean alone—the Atlantic. It had for upper Chagres regulation a massive solid dam at Gamboa.

The Lindon Bates project was, in treatment of the river, radically and fundamentally different. First, it divided the river. Second, it used the canal bed itself, always before avoided, instead of tunnels and diversions. Third, it discharged the Chagres to both oceans in controllable proportions. Fourth, it had at Gamboa, for upper regulation, an *undersluice* dam giving normally empty-basin control. On page 29, board report, there is a paragraph which reads as follows:

"At Obispo, where the Chagres cuts the canal line, Mr. Bates introduced a feature which he calls the Obispo triangle, designed to divide the flood waters of the Chagres entering the canal into two equal portions—one to flow through the canal prism toward Panama, and the other toward Colon. The accomplishment of this result is practically an impossibility."

Note, "The accomplishment of this result is practically an impossibility." The vote upon this section of the board's report is unanimous, and the Commission indorses it with the rest. It is further indorsed by the chief engineer.

From the first page to the closing page of this report from board and commission there is not one line, not one word crediting anything to the Bates projects. The Gillette project is adequately recognized and the Bunau-Varilla project is inserted in toto. The brief "Gatun dam" paper (see p. 27) to which the majority and minority give separate and special allusions (see pp. 27-77) was published in toto also. (The Bates feature of terminal lakes is not new.) There was place in the report for every project and brochure submitted, in the

terms elucidated by its author, but place for not a syllable of text from one. The only fair justification—but it would be an ample and final one—for silence and suppression would be that the Bates project and system was not used; that its ideas were not indorsed; that its treatments were not adopted.

We return. The verdict of the officials upon the Bates solution for the Chagres is: "The accomplishment of this result is practically an impossibility." The river is left to its Creator. There is no challenge as to *its* origin. "Mr. Bates introduces the feature." (Board report, p. 29.) The Chagres division near the Obispo triangle, carrying the discharge in two equal parts through the canal itself to two oceans, is conceded to be a Bates proposal and is "impracticable." So, of course, gentlemen, it will not be employed. It will not be found incorporated bodily and openly into any of the three recommended projects. We have the privilege now of examining the sea-level design. The plans submitted to the Board had been, remember, in the possession of two Commissions since the taking over of the canal.

You have the three maps of the submitted sea level, 85 feet, and Comite Technique. Not one, you see, has a divided river. Now, when the sea-level project comes out from the Board *it has no tunnel*. What has become of the \$8,000,000 tunnel? After the triumphant heralding "a place has been found for the tunnel" (see the report of 1904), lo, it has disappeared! What has become of it? Page 45, Board report, middle paragraph, begins, "As to a part of the upper Chagres discharge *will flow to the Pacific*." We are getting upon the track of the vanished tunnel. Having *divided the river*, the tunnel was, of course, not needed, and it was abandoned. No member of the visiting board even went near its site at Panama.

CANAL PRISM.

Is any other feature of this disapproved river regulation adopted? The Bates project alone used the *canal bed* for the discharge. This has been heretofore deprecated. The old sea level incorporated *diversions* overhanging the canal for 20 miles in menace. Is the *canal bed* utilized anywhere? Page 44, Board report, "but the plans for a sea-level canal contemplate a provision which would permit the discharge *through the canal prism*." Indeed! "And regulating sluices near the tidal lock on the *Pacific side*—dividing the flow between the *two oceans*." Canal prism! Pacific side! Two oceans! Yes; we know at last what has become of the tunnel.

DISCHARGE QUANTITIES.

Next, as to discharge quantities: "Designed to divide the flow waters of the Chagres entering the canal into two equal portions."

It will be first remarked that all propositions made are made within the limitations of sanity. Manifestly one does not dip up an onward flowing river to count its drops and set them carefully back. That a spoonful more shall not attain the ultimate Atlantic than the ultimate Pacific he would hardly have ventured to claim. Does fair Portia speak "nor cut thou less nor more, but just a pound of flesh; nay if the scale do turn but in the estimate of a hair thou diest?"

Is the practicability of dividing the Chagres like the Gueber's death bridge, no wider than a sword blade; and is the Panama Canal walking blindfold across it to paradise or perdition? Let us look.

Portia is very exact as to that drop of blood. The halving of the upper river is a very precise matter, and its division if less than that of two absolutely equal portions is "practically an impossibility."

Page 44, Board report, reads:

"Regulating sluices near the tidal lock on the Pacific side of approximately *one-third* of the Gamboa discharge, and to that extent *at least*, mark you, dividing the flow between the two oceans and consequently reducing the current velocity."

One-third at least! One-half along either slope was, in illustration, the Bates division. One-third at least is the majority division. The difference between one-third and one-half is one-sixth. Less than a sixth, may be a seventh, or a seventieth, one can not say which. How large a fraction of this one-sixth was needed to raise the dividing of the Chagres from the "practically impossible" to the perfectly ideal?

And lastly for the denouement. On March 7 the exponent member of the Board testified under oath as follows:

"Senator MORGAN. And some curvatures to pass?

"Mr. BURR. Yes; some curvature; very easy curvature.

"Senator MORGAN. Emphasis seems to be laid by some of the engineers upon the proposition that navigation through that part of the canal would be perilous, or would require very great caution, even under normal conditions of water supply; and that opinion seems to be intensified in respect to the situation that would be created by the incoming of waters from the Pacific or the outgoing of waters from the Pacific in combination with a flood in the Chagres.

"Mr. BURR. The waters from the Chagres floods would only be permitted to enter the canal by these controlling works at such a rate as would not make a current of over a mile and a quarter an hour at most.

"Senator MORGAN. But that current might go either way.

"Mr. BURR. If the current goes both ways, if it were equally divided and should go both ways, it would only be half that.

"Senator MORGAN. Yes.

"Mr. BURR. So that even if it all goes one way, even if it went toward the Pacific, which is scarcely conceivable, there would be no current—experience shows that—which would be materially inconvenient to navigation.

"Senator MORGAN. You say experience shows it. I suppose you have some model or plan which looks exactly like this?

"Mr. BURR. No; we have more conclusive evidence than would be shown by a model. We have the evidence of the navigation of the Suez Canal, where the curvature is not so very different from that which would exist in the sea-level canal, and with a much narrower prism."

Half or even all of the upper Chagres through the canal to the Pacific.

The stone which the builders rejected the same is become in very truth the head of the corner of the sea level.

TERMINAL LOCK SITES.

Are there any further features of change in Commission projects bringing them into identity with those of the writer? When the sea level and old 85 feet entered the Board, the Pacific terminal lock sites were for both, at Miraflores.

The Bates project set its end lock at Sosa-Ancon. As early as 1859 was laid down the supreme law for Panama—"end locks should be the closest possible to the coast." Miraflores was the site heretofore supposed the outermost available for a terminal Pacific lock. The writer saw differently, and maintained that the correct place was Sosa-Ancon. He claimed to have sufficient data to assert that rock foundations existed here, and hence that his contention was incontrovertible. The command of the President had been that all data necessary for judging projects be gotten for the Board. Wishing to be beyond challenge he formally requested that contours and borings be gotten on the sites of his two terminal locks—Ancon-Sosa and Mindi. His project was submitted by the Commission to the Board September 1, with this observation (page 11): "To obtain this (the Bates data) extensive additional surveys to occupy at least a year's time would be necessary."

Page 25 states from the Board:

"It early became apparent that additional information was desirable relating particularly to the possible dam and lock sites at Mindi-Gatun and in the vicinity of La Boca. The Board requested the Isthmian Canal Commission to have further examinations made as follows: * * *

Page 26 continues:

"Borings were taken across the valley along the lines indicated and this information was forwarded for consideration to the Board. The borings in the vicinity of Sosa-Ancon Hill, as well as those in the marine section, were given on Pl. VII. They show the practicability of a lock in the Ancon-Sosa saddle and also at the westerly foot of Sosa Hill."

The explorations, therefore, which were to have consumed a year when the Bates project was concerned, were forthcoming, while the Board still sat, when they unanimously decided to shift their end lock sites.

The writer's contentions regarding the Sosa-Ancon lock site being vindicated, the complete Board, both majority and minority, and Commission transferred themselves to his designated location. On its foundation (thus sustained) the majority set its one tide lock and the others their tier of two locks.

Next, what befell at Mindi, his Atlantic terminal lock site? The axiom, "end locks the closest possible to the sea," should, winning out thus openly at Ancon-Sosa, have won out also at Mindi. Why did it not?

The favorable report of Mr. Maltby, the engineer designated to get the data for Mindi, is given on page 26. Yet no borings whatever on the dam sites were ordered. The callous indifference to an interest weighty and pregnant, as shall later be shown, for the whole future of the canal as this Atlantic terminal lock site is inconceivable. Mr. Maltby writes in his official letter: "This (Jamarillo) is the first hill on the right that we saw when we went down the Chagres River."

The international body apparently never put a foot on shore to examine the location. They passed by this and more hills in the launch, and their own engineer feels obliged to identify to them the district—Jamarillo Hill—"on the right that we saw." Little things have decided the destinies of momentous things at Panama. Again, as at Sosa-Ancon, the writer's every claim and contention are more than vindicated. But the French borings and cuttings and those made otherwise give rock foundations such that the availability of the Mindi site is made incontestable.

DIMENSIONS.

But we continue the comparison of the before and after of the International Board. The sea-level project, submitted September 1, gave for the canal bottom, at Culebra, a width of 150 feet and for canal depth of 35 feet. The Bates project gave a minimum average bottom width in rock of 200 feet and a depth of 40 feet. In his presentation he inserted a table of ship's growths and a diagram of a 35-foot canal with an existing Cunarder inserted. The vessel was seen to project beyond the bottom nearly 2 feet. This was an object lesson at least. As recently as seven months before this Board met the sea-level committee and the chief engineer had reported their latest design and estimate. It gave a 35-foot depth, and based upon this its entire design and estimate for the canal \$230,500,000.

How do the sea-level dimensions come from the Board?

Page 57:

"In rock the bottom width was taken at 200 feet," etc.

Page 56:

"The depth of 40 feet was therefore adopted by the Board as the standard minimum depth in the canal."

GAMBOA DAM.

A much disputed problem was, of course, the upper Chagres regulation. How did the sea-level proposal of September 1 achieve this? It had a high lake impounded by a huge *solid* dam at Gamboa. Its lake was therefore incapable of being emptied save in its upper third, and then by means of a tunnel. In this full lake the Chagres floods were to be caught and held.

The Bates design opposed such a system of treatment. It set at Gamboa a low dam with *sluices*. Through these sluices the water, during normal discharges, was to be run off, thus keeping the water lowered to the lowest plane which the conditions admitted. In this basin of the lowest possible level (and normally it would have been empty, except for the silt trap) the excess floods were to be caught and imprisoned till the subsidence of the flood situation admitted of their gradual discharge. This constituted the last feature enumerated for his Chagres solution—the normally empty basin control. The sea-level *solid* dam did not, you remember, discharge their lake. This was its September 1 solution. What solution came out of the Board?

The sea-level type of dam for Gamboa is given on page 44 of the majority report. We read:

"So that if 15,000 feet of flood water per second from the Chagres be permitted to *enter the canal prism at Gamboa*," etc.

A solid earth dam? No; *an under-sluice* masonry dam. And again:

"The plans for a sea-level canal contemplate a provision which would permit the discharge through the canal prism and regulating sluices near the tidal lock on the Pacific side of approximately *one-third of this Gamboa discharge*, and to that extent *at least* dividing the flow between the two oceans, and consequently reducing the current velocity. * * * The Board has therefore assumed that the *controlling sluices to be provided in the Gamboa dam* may admit the flood waters of the Chagres to the canal prism at the uniform maximum rate of 15,000 cubic feet per second."

And again:

"A uniform outflow from the lake at the rate of 15,000 cubic feet per second would discharge the entire maximum average forty-eight-hour flow of the 1879 flood in eight and seven-tenths days. It is seen, therefore, that there would be no practical difficulty in *depressing the surface of the waters in Gamboa Lake* between two severe floods sufficiently to receive the entire maximum average forty-eight-hour flow of such a phenomenal flood as that of 1879."

Depressing the surface of the waters!

So the last feature of the Bates conception is taken with the rest. The whole upper Chagres, carried through an under-sluice dam at Gamboa as the writer proposed, divided near Obispo and reduced to harmless currents, and then borne in the canal bed itself to the two distant oceans—this is the solution of floods which comes out of the International Board as the "*majority design*" for the Panama Canal.

SITES OF OTHER DAMS.

Are there any further resemblances? Are there changes in other features of either Commission project? The 85 feet went to the Board with a huge dam under 85 feet of head at Bohio.

The Bates presentation claimed that this position limited the lock supply and was for a massive high masonry-core dam unfeasible on the revelation of borings (p. 13, Bates report). Yet the Commission projects, though two years under American study, brought in no recommendations except for abandoning Bohio and adopting a sea-level and tunnel scheme. Their 85-foot plan incorporated the same massive dam as heretofore and their project went to the Board with this same feature.

The Bates project, condemning Bohio, set a dam at Gatun instead, a small dam under a 29-foot net head.

The Bates design set also a dam at La Boca and a barrage from Ancon Hill to Sosa. Neither official project had any such feature. When the Board has reported we read for the minority (p. 77):

"The principal dam is the one at La Boca, which extends from the locks at Sosa Hill, across the mouth of the Rio Grande, to San Juan Hill. The other dam extends from Sosa Hill to Ancon Hill and from Ancon Hill in the direction of Corozal to high lands just across the Panama Railroad."

A last comparison.

SALT OR FRESH WATER HARBOR.

One of the fundamental features of the writer's design was a combination of salt and fresh water harbors at the termini. He

pointed out at length the great superiority of such an arrangement in facility and safety and healthfulness for commerce.

Neither Commission design, as submitted September 1, had combined harbors. How do they emerge from the Board? The maps are before you. You will find on the Pacific the minority in possession of the combined fresh and salt water harbors, but separated by two locks.

NEXT AS TO TERMINAL LAKES.

A remark let drop recently intimated that there was a surprise in store on terminal lakes. The card is now played—"The Bates feature of terminal lakes is not new." (See pp. 27 and 77, Board report.) The speaker owns frankly that he did not know in February (1905) that in 1880, at a meeting held in New York, when he lived in Oregon, a paper of nearly two pages and a half (republished in 1904) was read upon "A Gatun dam." The pains with which both parties, separately, and the full Board at the very opening of its remarks, announces the existence of this paper, brings the deliberations of the International Board convened for the purpose of discovering the best type of canal for Panama dangerously close to the humorous. Both parties, majority and minority, have adopted terminal lakes for the best lock plans. The Bates project alone of those submitted to the Board incorporated terminal lakes. The feature is nowhere credited to Mr. Bates; instead there is this careful assignment of it to two sources—one of 1879, one of 1880.

The majority does not state the 1879 source of the Board's inspiration. The minority, however, does. On page 77 the author who first gave them their concept is announced—Mr. Kleitz of 1879: "The idea of building dams and forming lakes at or near the ends of the canal is not new. As it was suggested by Mr. Kleitz at the International Congress of Engineers at Paris in 1879."

The writer laid down the preamble that the long succession of committees and Commissions in charge of the Panama Canal were to be held intelligent, informed, and conscientious. That if at any stage of development ideas were advanced and were by the type's own advocates declined, it was rational and alone honorable to infer that the idea was rejected because, according to the Commissions' best light, it was not as then submitted desirable for the canals as at that date evolved. If, then, no official project entered the International Board with terminal lakes, the only fair inference is that the two Commissions which had held under continued examination since the canal came into American possession, their sea-level and high-lock designs had either not known of the terminal lake conception or had not up to that date deemed terminal lakes desirable.

Now both majority and minority accept end lakes, and both put forth to cover the incorporation Mr. Kleitz of 1879 and the Gatun dam paper of 1880. The Commission had the Bates brochure six months, lacking five days, when it was sent to the International Board. The Commission submitted it for examination, with this introduction (p. 11):

"The Bates project, which is interesting on account of its novelty, and is therefore laid before you."

The Bates presentation had been studied, for the Commission adds that "It does not give detail enough for a close analysis" (p. 11). The final presentation supplied this fully, however.

Now, no one will precede the writer in maintaining proprietorship of ideas. Ideas lie in that intangible realm where legal claim is evasive, and where, therefore, moral claim is tenfold binding. He commends fully the desire of the Board to pay tribute to the mind that inspired them with the conception of end lakes. Their combined acceptance proves this feature to have been extremely *valuable* for the canal. Neither of the Commissions advanced the proposal before. Both *take* it now. They are right to go back to that far day of 1879 and give credit to the man who supplied them with it. The writer goes back with them to lend his presence to this befitting, even though 25-year-old homage to Mr. Kleitz of 1879.

The official report of the 1879 Paris congress includes all the technical subcommittee reports. It is a bit awkward, is it not, that Mr. Kleitz, here at last crowned, did not submit an idea for a terminal lake—that Mr. Kleitz did not have in his project a terminal lake? Pages 384 to 389, inclusive, of the official report of the Paris congress gives the Kleitz contribution. It reads (the note of M. Kleitz): "Possibilities of a lockless river for the Panama Canal."

Kleitz was a well-known mathematician. His four-page presentation gives a series of calculations upon Chagres discharge. It concludes that to construct a lockless waterway would necessitate "turning from the canal itself all the waters of this river."

Since the publication of this report compelled the writer's inspection of these very early and long-buried records of the declined, in Panama engineering history, he has dug up the story of the terminal-lake conception. For his own sake, in defense of truth and history, he wishes therefore to take this idea back and give credit to the first man who did conceive it. He needs to snatch no wreaths from graves to save his project. Instead, he goes back to 1859 and lays this belated homage at the feet of that clear-seeing engineer, Godin de Lepinay. He writes:

"I thought of it in 1859, when I was designated by the minister to go to Darien. I believe I spoke to Mr. Blanchet regarding the incorporation of this idea into his Nicaragua Canal."

De Lepinay's injunction shows the master insight. He writes:

"The barrages shall be placed as close to the sea as the configuration of the land admits, *perhaps at Gatun*; if not, then certainly at Bohio-Soldado."

De Lepinay's report was not published by the congress. The only clue remaining by which to trace the history lies in these two remarks made in a subcommittee meeting.

But the Congress relegated his conception to defeat. Some way and somehow, for the lock canals as then designed, his idea did not fit, according to the judgment of the world-famed engineers sitting there on the types.

The *final vote* in the general congress of Mr. Kleitz and the announced *abstention* of M. de Lepinay make striking history. The first voted for the sea level. The latter announced his strong opposition to the sea level in these words:

"All my conscience is intensely enlisted. I am the only French engineer a member of this congress who has executed works in that

country there. If I have not known how to make my advice triumph, I can not let it be believed that I abandon it, all unknown though I am. I shall have gone out of this assembly, as others have done, that I may not leave my name subscribed to a measure disastrous.

"Finally, and this is the greatest with me—me who has executed works in that tropical America: Reducing these insanitary works to their minimum (the lock type) spares the life of more than 50,000 men uselessly sacrificed for the execution of a sea-level project. To not charge my conscience with these unnecessary deaths and the loss of a considerable capital, I abstain, or I vote 'No.'"

Two men in the subcommittee, however, seemed to have been impressed and to have believed that better study might have wrung grace out of this conception. These two men were American. The book of these delegates, of whom Menocal was one, speaks in a place, the writer discovers, of de Lepinay's proposal for a *Gatun dam*. This book reads:

"Entered by act of Congress in 1879." It was published in Philadelphia. De Lepinay's idea, therefore, comes straight in descent to Philadelphia and in the year 1879. The small New York meeting was discussing Panama. The 1880 leaflet begins (Appendix I): "In a paper entitled 'Interoceanic Canal Projects, by A. G. Menocal.'" The writer was studying Menocal. What becomes of Gatun dam paternity in 1880?

But it matters not one hair's weight to anything save history. The true goal is the present, the best project here and now for the Panama Canal. The writer was not concerned with the Commissions' designs. He was not seeking to reform an old order; he was establishing a new order, radically different and antagonistic to what had gone before. He outlined his claims, and he did it unmistakably on page 17 of his presentation. It reads:

"These three factors, then, the terminal lakes, empty basin and divided control of the Chagres, and terminal harbors of original and strategic dispositions, go to make up a fundamentally new system upon which may be fashioned the concrete plans for the American canal. It is manifest that such a combination of engineering mechanisms can not be narrowly conceived as bounded by one or two detailed schemes with metes and bounds of location and dimension. Under the new system there are possible several plans. The terminal lakes can be made at a higher or lower level and the discharge at this or that alternative location; the empty basin sluice control can be effected by one or two or three dams at various heights and sites. The terminal harbors may be changed as to breakwater, form, alignment, or other details. But the principles and the systems remain unaltered as a new conception and proposal."

"The author has, it is true, specified and developed definitely from all the data available what he holds to be the best plan under his system. But these are only parts of a greater whole. It is not project A or B or any modification that go to make up the claim to a new canal. It is the inclusive system of lakes, Chagres control, and terminal harbors whose principles are fundamentally original."

What are the elements of the Panama Canal? Dam sites and water sites, dams of different types and heights, varying levels, treatments of rivers—such and such only. An engineer does not create elements; he can but combine. The writer had only the same elements as were

possessed by every man since 1859. These had been through half a century shuffled and reshuffled, combined and recombined. If at last in the year 1905 he, shuffling still another time, combines differently, treats antagonistically, and applies the world-old principles in a new method, has he done nothing?

Howe did not create the thread, nor the needle, nor the iron, nor the bands, yet no one disputes him the inventor of the sewing machine. The right to new combinations is the basis of the whole world system of patents. And in the Patent Office there is an antipodes of difference, a great gulf fixed, between combinations which *will* work and combinations which *will not*. The first man who makes a *workable* tool is its creator, no matter how many myriads may have had its elements before. So the discovery of a terminal-lake conception, dating back to 1859, matters not one breath in this discussion.

It is seen, therefore, that every primary element and treatment of the Bates canal, from its Atlantic lock to its Pacific lock, and including its complete Chagres River solution, is found accepted and adopted by one or other of these three Board projects. His canal is therefore much better accredited than any other, for the old designs differ radically and fundamentally from each other.

SIMILARITY BETWEEN BATES PROJECT B AND THE 60-FOOT DESIGN
RECOMMENDED BY THE MAJORITY AS THE BEST LOCK CANAL FOR
PANAMA.

A few facts must be remembered. First, the *exact* best level for the summit stretch of any canal of lock type should not be decided finally and inexorably at the Isthmus until more complete and exact surveys have been made. One of the vital determining factors must always be the quantity and quality of Culebra cut. Through this massive rock barrier it is desirable to demand the least excavation advisable in a four-lock canal. The difference of an inch or two, even of a foot or two, in level is not fateful one way or the other or inherently momentous, while it may mean a very material difference in what is to be gotten out, and hence to the cost of the canal. It is not wise, therefore, to narrow to the inch here on the threshold the level and set up a fixed and immovable prohibitive against the small adjustment, which may be found to mean a great difference in expense. While, therefore, the writer set his summit level of B at 62.5, he noted the need for this small margin of elasticity, and stated that the level should be no more arbitrarily fixed than that the canal's summit level should be about +62.5.

A second determining element was the height accepted for lock lifts. His projects allowed its willingness to consider as safe locks of up to 36 feet lift. Certain limits, therefore, like these were established on certain features determining important issues, but a definite selection and preference was, notwithstanding, announced for each item. Second, awaiting the final contours and borings at Sosa-Ancon and Mindi, he selected alternative sites. On the Atlantic he gave Gatun as his second or alternative location, always announcing, however, that Mindi was first. But the final and controlling borings had (as was said) not yet been reported.

Far be it from the writer to claim any monopoly of ideas for

Panama. He has but his small pint cup dipping into the vast, infinite ocean of thought. Many men, many minds.

The International Board was obligated to draw out new ideas. These ideas were almost equally bound to lead to the betterment of the two canal types. He is neither so blind nor so foolish as to fancy that some of these alterations, like the change of dimensions, would not have come, probably here and now, if he had never lived. All he does say is that he has proved a passing good prophet in his own country for what the future was destined to hold, and that he anticipated and provided much that this International Board was fated to want.

Lindon W. Bates's project B—Recommended majority lock project, 60 feet.

[Board report, p. 35, project IV.]

	Board lock +60 feet.	Project B.
First lock.....	Gatun	(First choice) Brochure 1, page Pl. IV, Mindi or Gatun.
Lift first lock.....	30 feet	27 to 33.5 feet.
First dam	Gatun	Mindi first choice, Gatun second choice.
Second lock	Bohio	Gatun first choice, Bohio second choice.
Second dam	do	Do.
Head first dam	30 feet mean	27 to 33.5 feet.
Head second dam	do	29 to 31 feet net.
Type first dam	Undersluice and earth	Undersluice and earth.
Type second dam	do	Do.
Gumboa dam	180-foot crest	Crest at +118.8.
Gumboa dam type	Undersluice	Undersluice.
Third lock	Pedro Miguel	Pedro Miguel.
Summit level	60 feet	62.5 feet.
Fourth lock	Sosa (west side, but east preferred).	Sosa (east or west side; east preferred).
Spillway and lock	Separated	Together preferred; separate admitted.
La Boca dam	Same	Same.
Sosa lock	26 to 35.5 feet lift	26 to 35.5 feet lift.
Panama Lake	26.5 feet	26.5 feet.
Alignment	Identical (Mindi to islands).	Identical (Mindi to islands, variant B.).
Usable length locks	1,000 feet	1,000 feet.
Depth	40 feet	40 feet.

OBISPO BASIN.

The elevation of the bed of the Chagres opposite Bas Obispo is about +45. In all the canal projects before the Congress the drainage discharge of the upper Chagres meets here the canal channel at right angles. The water, therefore, must by force of the natural conformation *itself* divide. Local conditions, of course, determine the exact parting of the water, which will vary within limits and can be varied as to relative amounts going each way by manipulation of the sluices at each end of the summit level. The +85 lake waters divide and flow both ways from this natural triangle. Part go north, because there are escape sluices in the Gatun dam; part go south, because there are locks and sluices at Pedro Miguel and because the +55 lake of the minority must be filled and fed against the losses of percolation, infiltration, evaporation, and gate leakage.

The decision in favor of two outlets through the navigated waterway—a treatment found in neither project when it entered the Board, but adopted by both majority and minority *now*, compels a dividing of the Chagres in the so-called Obispo basin. All projects before the Senate committee—sea-level, minority, majority, 60-foot, and Bates—all have a body of water which *divides itself* at or near

the Obispo basin. Not precisely "automatically," but as the result of mechanical manipulation. This the writer has advocated.

The same is avowedly true of the sea-level plan. After condemning and repudiating this principle, both the majority and minority make it an integral and vital factor of their deliverances.

Into what, for a name, was termed by the writer "the Obispo triangle," the sea-level allows 15,000 cubic foot-seconds to emerge from the Gamboa sluices and sends, as they state, *one-third* out of the sluices at Corozal and *two-thirds* to the Atlantic. Such careful fractions!

The cutting of the canal makes a *delta* for the Chagres with two mouths, and a delta is a triangle in the Greek alphabet. In order that the upper Chagres water and the currents—whether emerging from Gamboa sluices or from an arm of the +85 or +62.5 lake—shall not interfere with traffic passing at right angles, certain work is necessary. The borders of the basin should be trimmed to the best shape and the basin should be made deep and large enough to absorb the currents and create a turning basin.

Navigable depth is wanted.

The sea level has here the most to do. It must excavate some 85 feet and shape the basin to the semblance of a triangle. As the summit level is raised the amount of work needed diminishes and the natural borders of the triangular basin enlarge.

The +85 plan has a little less to do here than project B at +62.5. All plans should so arrange that a 1,000-foot ship shall be enabled to turn around. Project B requires but 300,000 cubic yards of excavation here.

+85 LAKE.

The monstrous dam and staircase of locks at Gatun—too small for commerce and too big for their site—make a high navigable lake. This lake is so high that it makes a continuous railway all but impracticable. But of this anon. The lake leads to a 45-foot minimum channel through the sunken valleys and the central mass. Such a depth is good. It is better than the old 35 feet of the Walker Commission, but it is not *yet* what is necessary. The minority gives over gate sills but 40 feet of water. To change this must stop trade some day, or they must build new and larger and deeper locks. But there is no room for larger and deeper locks at Gatun.

It seemed to the writer better to design his gates and structures so that in the future—after the dams and locks have stood the tests of time—the lake levels might be raised 1, 2, 3, 4, or 5 feet, keeping pace with the demands of commerce. It is certainly cheaper to deepen by regulating the lake discharge sluices than to dig rock for 8 or 10 miles, 5 unnecessary feet through the Culebra, with all this means of bottom and slope excavation.

The minority do not wish to raise their lake head to 90 feet, evidently. Thus it comes that in reality the bottom of the central summit level of B is but 17.5 feet lower than that of the minority.

The elaborate summary of "navigable widths" is misleading. What a vessel wants for good steering is top width to the channel section, and buoying in a submerged lake channel does not limit speed, as averred. Vessels can pass each other as well in the +62.5 lake as in the +85 lake. The side hills are nearly everywhere steep, and the two

contours where they are important to the channel are little apart horizontally.

The +85 lake is announced to be a better receptacle for floods, so really floods are not regulated by any sluice dam in entering their lake. Those into his lake are controlled by the Gamboa, Cano, and Alhajuela dams of project B.

The flow line of the +62.5 includes the mouths of the Palenque and Chilibre rivers beyond Gamboa, and the +85 goes only a little farther. Which is the safer flood regulation, this or to have two normally empty basins above the flow line, dividing the entering rush in two parts and setting the areas of disturbance some miles farther from the navigated channel?

Project B has *both lake and double under-sluice* regulation, while the +85 has *only lake* regulation. Which has the larger factor of safety against such a flood as that of 1879? Does a margin of narrow waterway averaging but 11 feet deep, such as exists between the flow lines of the +62.5 and +85, give more security than under-sluice dams and their reservoirs ready for instant service above Gamboa and Alhajuela?

The writer fails utterly to see where and how this indefinitely controlled upper Chagres flood regulation is worth the offset of two locks and all that they mean to vessels, together with an unparalleled dam and all the attendant elements of cost, delay, difficulty, and perpetually increased risks.

DISTRIBUTION OF CULEBRA MATERIAL.—END DAMS AND LAKE.

There remains to be excavated under the minority plan 53,800,000 cubic yards from the Culebra section. But nowhere in their report do they say what they propose to do with it. The chief engineer testifies that it would be a good thing to mix it with the mud batter and put it in the Gatun dam, but he tells not how much. He would also put some "below Bohio." (See testimony before Senate committee.) It is understood that he proposes to haul half each way somewhere from the center of the great cut. So we must assume, in tracing vaguely what is intended that about 27,000,000 cubic yards go toward the Pacific. Apparently (p. 245) there go to—

	Cubic yards.
Back filling and embankment, Pedro Miguel.....	390,000
Dam, Pedro Miguel.....	1,100,000

which, however, is offset by the excavation from mile 39.60 to 41.47, totaling 1,460,000 cubic yards.

They likewise seem to have—

	Cubic yards.
Mile 41.67 to 45.08.....	220,000
Excess from Sosa lock.....	480,000
Outside the lock.....	5,330,000
Total	6,030,000

The Ancon-Sosa, Ancon-Corozal, and La Boca dams require 12,280,000 cubic yards. It is unlikely that over 1,280,000 cubic yards from the above 6,030,000 cubic yards would go into the dams from the dredges. This leaves to go into the Panama dams from Culebra 11,000,000 cubic yards, and 16,000,000 cubic yards to go somewhere outside of "Lake Sosa." Possibly some 6,000,000 may go into the

space east of the Ancon-Corozal dam, providing the drainage of the Juan Diaz and Puente creeks is properly cared for—something which the minority overlooked. A considerable area is drained by these creeks, but no provision is apparently made for their run-off. There remains 10,000,000 cubic yards to go where? To sea by barges. This would be a waste of opportunity to make breakwaters to the islands or reclamations, serving a useful, valuable, or military purpose.

We have heard much of the French transporting Culebra spoil uphill, but it is not recalled that they ever were guilty of proposing to haul 11,000,000 cubic yards downhill and then hoist it into huge high-head dams overhanging Panama or of bringing 20,000,000 cubic yards to Gatun.

PANAMA AND BALBOA DAMS.

If the Ancon-Corozal dam, with 55 feet of water behind it, should get an earthquake crack, the survivors of the city, if there were any, might return to the "ruins of old Panama." There would be nothing left of new Panama.

It and the La Boca and Sosa dams total 12,150 feet long—over 2 miles. In project B there is one rock-and-earth-fill dam of one-third this length and one-half the head and height. It contains no menace to the city. Project B requires no Ancon-Corozal dam, because a trifling embankment a few feet high eastward from Santa Cruz on the railway, at the foot of Ancon Hill, defines the Lake Panama of project B and solves the drainage of the creeks, lately mentioned, without expense.

There is a vast difference between the cost and hazard attaching to the minority's end lake "Sosa" and the one the writer baptized in this valley as Lake Panama.

It is rather of interest to note that when the writer's brochure was published a year ago there were no foundations for end locks and dams but "mud," and no one in authority knew this site from 1879 till then. Now the condemned locations are reluctantly bored, and lo! rock is nearer to the surface than at any dam site on the canal, except at Alhajuela. It will be the same story at Mindi. There are nine separate hard hillocks in the axis of this Mindi dam over 40 feet high. The bases of these knobs are only 200 or 300 feet apart.

Lake Sosa indeed saves a little rock and mud dredging, but it introduces a number of serious and expensive difficulties of execution. Lake Panama, half as high, is a simple affair by comparison. The writer conceives that no useful purpose to navigation is served by the higher lake, which likewise imposes an entire relocation of the railway below Pedro Miguel. The lower lake merely requires the small amount of grade raising shown on the plate of Colonel Totten's map, about the only thing showing the character of the topography east of Panama in the Washington office of the Commission.

DISTRIBUTION OF SEA-LEVEL SPOIL, CULEBRA.

Nowhere in their report that one can discover have the majority said what they are going to do with Culebra or other excavations. One sees much of steam shovels and a reference to "transport being the principal isthmian problem." Quotations from Board report:

Page 60—

"The Board recognizes that the removal of the material in the summit cut is in reality a problem of transportation. It is a comparatively simple matter to excavate the material within a much shorter time than that allowed for the work, even on the supposition that all of it except the clay near the surface must be shattered by preliminary blasting. The whole difficulty attending this part of the construction of the canal is attached to the removal of the material from the shovels or other excavators to the spoil banks. This problem of transportation is in reality the substance of the problem of building the transisthmian canal, and in treating this part of the project the Board realizes and has considered the large amount of railroad track and the extensive transportation organization required for the disposition of the waste material. It is probable, as has been estimated, that not less than 3 miles of standard track will be required for each shovel employed, making a total of 300 miles of trackage for 100 shovels.

"It is assumed that 100 shovels are available for continuous work, there being a sufficient surplus above that number undergoing repairs whenever necessary to maintain the working complement, it can be demonstrated that as much as 20,000,000 cubic yards of material classed as rock may be annually removed from the summit cut."

Page 60:

"The time required to remove this great mass of material, by far the greater part being soft and hard rock, will depend greatly upon the efficiency of the method of operation and the organization of force and plant, all of which must be ultimately the result of most careful consideration of all the elements, including those of climate and character of labor available."

Page 61:

"It is found that the entire quantity of 110,000,000 cubic yards of material in the divide can be removed within ten years. (For time curve, illustrating practicable excavation of Culebra cut, see Pl. XXXI.)"

Where does it go? They demur to the Panama breakwaters or to an "ambitious" reclamation of the Panama tide lands, making a useful property, even if "many times in extent the area occupied by the present city itself." For which latter reason they condemn it. The Rio Grande Valley is preempted for adjacent excavations and the care of its watershed, whence 6,000 cubic foot-seconds must sometimes run off.

So it must be that it is to be taken in barges to sea—what a waste! And what a travesty that the principal problem of the Isthmus—"transport"—remains as to estimation so far as they enlighten us (they or the ex-chief engineer either in his appendixes) still a riddle and a mystery.

CULEBRA SECTIONS.—TYPICAL SECTIONS.

The typical sections adopted for the Culebra cut are shown on the plates which accompany this review. Those taken by the writer are in substantial agreement as to slopes and terrace widths with those evolved by the French engineers and the Commission of 1901, except that the waterway is enlarged to a minimum of 8,000 square feet. The surface width is 210 feet and is preferred to the Board's

208 feet. The bottom width is 190 feet to the Board's 200 feet, but he has planned a gradually enlarged section of Pedro Miguel to take care of surface drainage from the terraces. The minimum ruling section below the water surface is practically the same. Practically all plans must yield and be adapted to the conditions found when the excavations uncover the formation now out of sight and definite knowledge.

Above water the Board and minority make a wider berm than the writer and diminish the width of the terrace above to the rock line, and they plan higher terrace steps. In such broken and varied formation and having regard to the *sudden* character of the tropic downpours, the writer believes it ill advised to thus diminish the terrace widths and the number of longitudinal drainage ditches. Above the "rock line" the Board make a long flat slope, which naturally concentrates all that falls on the "earth" slope on the upper terrace, whose width the minority, under such conditions, advisedly makes 50 feet.

But it seems to the writer that the terrace system should not stop at the "rock line," a most ill-defined and variable thing. It should extend nearly to the top of the cutting, the risers lower and treads of the steps wider, and the average earth slopes one to one and a half.

CULEBRA ESTIMATES.

The quantities appearing in the writer's presentation have been questioned. This contingency was foreseen and allowed for by the writer, because he did not have and could not get the detailed cross sections and station estimates. This he covered in a contingent item of \$10,000,000 to meet extra excavation or bank protection which circumstances might develop (vide p. 263). This sum, for illustration, will excavate 16,666,666 cubic yards, at 60 cents per cubic yard—a figure ample because the plant is amortized against the main quantities. He does not subscribe to taking the unit prices of the Board (based at Culebra upon steam-shovel method alone), as stated on page 29. He knew then, as he knows now, that American contractors and men accustomed to devising and applying methods to new conditions had never been given a particle of opportunity to apply their talents to the Culebra problem of excavation and distribution. Besides this, he specifically stated that he attached some value to the money expended to September 1, 1905, in the following terms (p. 263, Board report):

"NOTE II.—It must be borne in mind that during the past eighteen months large sums have been expended on the Isthmus, and the value of this work reduces the unit prices of Item IV."

The shovel commitment was taken out of hand and without due consideration by men inexperienced in canal work or in the Tropics. The steam shovel is a temperate-zone tool and ill adapted to working efficiently during three-quarters of the year because of rain. To pit the 20-year-old French excavateurs against modern steam shovels is ridiculous. The fact should be here registered that where the ground suits the modern excavateur it is far ahead of its ancient prototype, and is a better tropic tool, because it is more automatic and depends for efficiency far less upon the human equation. It leaves its terrace in a smooth, not in the broken condition charac-

teristic of steam-shovel work; but the progress of this implement was never fairly investigated. There are also inherent possibilities of rapid and cheap work during the rainy season in the cantilever crane and cableway equipped with proper grab buckets which should not be ignored, and they have been.

DEPTH OF PANAMA APPROACH.

We make the following quotations from the Board report:

Page 50:

"Beyond this tidal lock there is to be a straight channel projected into Panama Bay, with a bottom width of 300 feet and extending for a distance of $3\frac{1}{4}$ miles to the 45-foot contour." (Contours refer to mean sea level.)

Page 55:

"The bottom width of the entrance channel leading from deep water off the island of Flamenco to the tidal lock near Sosa Hill will be 300 feet, but the side slopes will depend upon the character of the material to be excavated. Inasmuch as extreme low water of spring tides will occur but rarely, the depth of excavation in this dredged channel is recommended to be but 45 feet below mean sea level. This excavation is sufficient to give at least 40 feet at low water for all but those spring tides having a range of more than 10 feet. As the mean tidal range in Panama Bay does not exceed about 14 feet, it is considered that the depth of excavated channel to be provided will never be a source of any inconvenience or any delay whatever for the great bulk of the traffic of the canal, the measure of the maximum inconvenience for ships of greatest draft seeking the canal, if they should be ready to enter it at extreme low water or at about that time, being a total of only two or three hours."

By examining the Official Tide Tables for 1906 one finds that 330 times in a year ($27\frac{1}{2}$ times per month) there will be *less than 37 feet* in this channel below mean sea level. The time when there will be but between 35 and 37 feet totals seven days. And there is a much longer total time when the depth is less than 40 feet, the standard, provided at Colon every day and hour in the year, according to both plans of the Board. The writer submits that the Board's conclusions are not well balanced in respect to this abridgement of the depth and width of the Pacific harbor facilities of the canal.

On chart No. 1042 are shown the contours of Panama Bay from mean sea level outside of the islands. This appears to show, further, that the approach shoals beyond their terminus and that the 45-foot contour below mean sea level is *a mile farther out*. This chart was not before the Board, who used chart No. 1950, which does not contain soundings far enough beyond the islands to disclose this condition on the canal axis.

Furthermore, 3,500 feet beyond their terminus, the sailing line, prolonged, passes over a rocky reef carrying but *30 feet* at mean low tide. It is some 750 feet across on the minority line. This sunken reef runs three-quarters of a mile in a direction 20 degrees north of east from the visible rocks called San Jose. The chart shows it to extend for *900 feet* directly athwart the entrance line. On the sea-level alignment the reef is over a mile wide and still shoaler.

Now, this reef is where there is positive wave motion enough to affect a large and deeply laden steamer. Hence for practical purposes of navigation it may be said to carry for the minority not more than 25 feet at mean low tide or 33 feet at mean sea level and less for the majority. The writer adheres to the view that this axial line is wrongly placed from the standpoint of the ship's draft, which, by law of Congress, must be observed. He still prefers the new alignment and harbor dispositions he advanced.

RELOCATION OF PANAMA RAILWAY +85 SCHEME.

We quote page 94 of the Board report:

"Between Mindi and Gatun recent surveys show that the work will not be particularly heavy or expensive. Between Gatun and Bohio no recent or complete surveys are available, but the information at hand is sufficient to show that a reasonably direct line crossing the lake and taking advantage of the support afforded by the highlands along the route is preferable to one going around the lake. There will be some heavy work along this line at the crossing of the Gatun and other valleys, the maximum height of embankment being about 80 feet, which is not unusual in railroad construction.

"From Pedro Miguel toward Panama the railroad may be located without special difficulty around the margin of Sosa Lake until the northerly end of the Ancon-Corozal dam is reached, and it can then run along this dam, which furnishes a direct route to Panama.

"For the 10 miles of relocation required between Mindi and Bohio, \$2,000,000 have been included in the estimate, and for the 6 miles between Pedro Miguel and Panama \$400,000 have been so included. The estimate of the Isthmian Canal Commission of 1899-1901 for 24.5 miles from Bohio to Pedro Miguel is, in round numbers, \$1,300,000, making the total estimated cost of the relocation of the railroad \$3,700,000."

This is a serious report. Let us examine this "80-foot embankment."

The Maltby survey is only from Colon to the Gatun ridge, a distance of 16,000 feet—3 miles. If the grade across Gatun Lake is put high enough to guard against the risks of subsidence and compression of the swamp muck, it is pretty safe to say that the embankment from the Gatun ridge to Tiger Hill will measure from top to bottom (including 10 per cent only for sinking of the swamp material) not 80 feet, but at least 90 feet in height. Doubtless it will be allowed a top width of 24 feet, and since it is across a lake the side slopes will be 3 to 1 and thoroughly riprapped on both sides, or built of rock spoil like the exposed front of the monster dam. Then we have a section which runs about 1,000 cubic yards per foot.

From the only surveys extant it appears that this embankment may total from 7,000 to 10,000 feet long, and must contain 7,000,000 to 10,000,000 cubic yards. And besides there are other great cuts and fills and bridges. One can not but think that the \$2,000,000 estimate for the "10 miles" to Bohio will be largely exceeded. No wonder the chief engineer, a practical railway man, says he does not think it will pay to build such a line.

Items not included in estimate of the Board for a sea-level plan or for the +85 of the Commission and minority.

On page 58 of the report occurs the following statement: "Total, \$247,021,200.

"The Board is confident that the Panama Canal can be constructed and completed under the plans set forth and recommended in this report within the preceding total sum of \$247,021,200.

"There are certain items of cost, such as construction of military defenses, naval stations, government of the Canal Zone, sanitation, light-houses, buoying, lighting, and the provision of tugs, lighters, derricks, dredges, scows, etc., which have not been included. They are common to any type of canal."

From this it appears that in addition to sanitation and Zone government there is omitted: Naval basins, buoying, lighting, tugs, lighters, dredges, scows, etc.

All these things are requisite to make the canal an operative national concern and were estimated in project B at \$1,680,000. (See p. 264, Bates project.)

Comparative concrete in locks and barrages.

[All 1,000-foot locks, except +85—900 feet.]

Lock.	No.	Bates B.	Unit price.	+ 85.	Unit price.	+80 Board.	Unit price.	Sea level.	Unit price.
		<i>Cu. yds.</i>		<i>Cu. yds.</i>		<i>Cu. yds.</i>		<i>Cu. yds.</i>	
Balboa.....	1	600,000	\$10.80		\$8.00				
Gatun.....	1	610,000	10.983	1,300,000	8.00	18,750 640,000 18,750	\$8.00		
Bohio.....						628,000	8.00		
Pedro Miguel....	1	590,000	11.07	552,750	8.00	18,750 600,000	8.00		
Sosa.....	1	611,000	10.80	828,650	8.00	18,750 600,000	8.00	490,000	\$8.00
		2,411,000		2,681,400		2,543,000		490,000	
Gamboa.....		280,000	21.50					6,000,000	8.00
Alhajuela.....		80,000	15.00			197,000	8.00		
Cano.....		80,000	19.00					(?)	
Gigante.....								(?)	
Total.....		2,851,000		2,681,500		2,740,000			

NOTE.—The unit price in project B includes all auxiliary work and mechanism at the locks.

It is further seen that the approximate quantities and lock costs agree very closely for single locks—the difference being merely due to minor questions of design. To make the locks of the +85 comparable with the others as to quantities, one must add 10 per cent, making a total of 268,140 cubic yards and adding about \$2,250,000 to the estimate for this minority type.

MILITARY ASPECT OF END LOCKS.

It is held to be the legitimate conclusion from the following analysis, that any and every canal here is vulnerable in so many ways that it is a serious mistake to sacrifice to a hypothetical military benefit which in reality does not exist, the highest commercial service of the waterway.

One variation of the minority plan would move the Ancon-Sosa terminal locks to Miraflores, and having moved the Pacific locks, the canal is judged safe when in the center of three lines of possible fire and when on the Atlantic side there is a huge staircase of three locks,

making a target three-fifths of a mile long and 250 feet wide, in Gatun Hill, fronting the Caribbean and 3 miles from Limon Bay.

The Chief engineer testified as follows before the Senate committee subsequent to his letter of January 26, to the Commission:

"I proposed about the same elevation—I think I said 80 feet—for the high-level canal, as is proposed in the minority report, and I proposed putting my entire lockage system at the south of Pedro Miguel and Miraflores there together, with this idea in view: That the locks at that point will be from $8\frac{1}{2}$ to 9 miles—we will say 8 miles—in a straight line from the nearest point where a ship can lie, providing she reduced the fortifications in the outer harbor. In other words, she would come up the mouth of the canal and could lie there, but she would have to throw a shell 8 or 9 miles before she could strike anything that she could damage.

"The same condition prevails exactly on the north end, with the dams at Gatun. It is about 8 or 9 miles to where a hostile ship could lie, unless she came directly into the canal. She would not have anything to shoot at. My notion is that, with a small object like a lock lying at an unknown point—unless the enemy had absolutely correct charts—a ship would have pretty hard work to do any damage at that distance."

The supposition that "after the harbor fortifications were reduced" the war vessel would not enter the canal, but would lie off only "8 or 9 miles" and shoot fatuously into the jungle is surely interesting as a warrant for spending more millions than all Alaska cost to dig through the slime-covered morass and buried rock ridges of the lower Rio Grande Valley. The practically minded admiral or general who "reduces the harbor fortifications" of Limon or Panama bays will reflect that he does not then need to shoot at locks, but rather must hasten to save them from the defenders, as the Japanese tried to save the docks at Dalny.

Another proposal is to slew the Ancon-Sosa lock so that it is nearly at right angles to the line of the canal, making every ship passing through for all ages turn around to enter and leave.

It is time, certainly, to reflect. There are no mysteries in the science of military offensive. Every admiralty will know to a dot just where the locks are, and precisely their relation to the zones and angles of fire and to the principal modes of attack from the sea. There are four ways that locks can be disabled from the sea.

(1) By gun fire.

Noting the progress of the past decade, the power of the present 12-inch and 16-inch guns, the constantly increasing range, the terrible accuracy developed, and the certainty that range and accuracy will increase, it needs small prevision to register the certainty that the $3\frac{1}{2}$ extra miles from Mindi to Gatun or the 4 extra miles from Sosa to Miraflores offer no tangibly greater security at the latter places from a 12 or a 16 inch gun shooting 10 or more miles.

It is well to note that the Commission, including four members bearing in their titles the evidence of military training and one actively experienced in defending the siege of Vicksburg, agree with both the Board and minority in not taking to the hills at Miraflores to "hide their locks."

(2) By dirigible balloons.

What does it matter to the new French dirigible dynamite air ships, one of which lately circled over the defenders of the border forts of Germany, whether their objective lock is on the shore or a few miles from it? A hostile fleet, without "reducing the harbor fortifications," could send fifty such balloons over any part of the canal's 47 miles.

(3) By submarines and torpedoes.

These constantly improving weapons of naval warfare, in daring hands, may be utilized. The locks most exposed are those of the minority at La Boca, because attacks could be launched from a wider zone. The tide lock of the majority is partially defended on the flanks by the low rock walls, which the latter suggest, parallel to the inner end of their approach. By far the best defense from this sort of attack would be the breakwaters inclosing the harbor. These breakwaters would compel such attacks to run the close gantlet of the channel between the islands and a boom across the entrance, while the other plans omit these, and their locks can not so well be defended by booms, nor can the enemy be so easily discovered.

(4) By stone ships.

The breakwaters likewise are evidently a better protection against these desperate ventures for blocking the channels than the meager provision of both the Board schemes. The breakwaters force such craft right between the point-blank cross fire of the island forts.

The true policy, military as well as commercial, is to build the best canal that science can evolve for navigation, and hold this isthmian gateway of the western continents. Make it of such a nature that its risks are averaged over a number of easily repaired units, not concentrated, as in one huge dam or flight of locks. Make the breakwaters and the inner fresh harbors; fortify the terminals and salient land points so effectively that the United States can not be dispossessed. The millions proposed to be invested in making a worse canal by moving the locks inland will be better employed when dedicated to creating suitable naval stations at each end and defenses that can not be reduced.

CRITICISM OF THE LINDON W. BATES PLAN BY THE BOARD OF CONSULTING ENGINEERS.

It behoves an engineer responsible for certain proposals fairly and squarely to meet any honest technical criticism. With the analysis made by the Board much time can be spared through eliminating the nonessentials.

The first paragraph, for instance, does not require refutation (p. 26):

"Mr. Bates presents three projects, designated A, B, and B'. He does not appear to attach great importance to the elevations of the lake surfaces shown in those projects, as the latter are modified to almost any extent under his general presentation."

Its general tone gives the impression to one not familiar with the plans that they are vague, uncertain, and merely general. That this is not the case is a matter of record. As well as outlining a new system of treatment, the project definitely gives with full detail the particulars of project B. The elevations are definitely given as Lake

Chagres 33.5 feet, Lake Gatun 62.5 feet, and Lake Panama 26.5 feet. Therefore, the first paragraph gives a *false* impression. It is not an engineering criticism to be combatted, because the presentation of September last from the first page to the last (p. 168) was a discussion and analysis. From that last page is quoted the conclusions reached—page 168 of "The Panama Canal system and projects:"

"Lockage being practically the same, therefore, for the two projects A and B, and over 50,000,000 tons, the preponderance of advantage, unless it be decided that the level of A can be advisedly raised, lies with project B with a Gatun dam.

"Therefore that application of the author's system which is incorporated into project B is the one which were best adopted for the American canal."

The second observation begins (p. 27), "The feature of terminal lakes is not new," etc.

Now, originality is not an engineering question which this Board was convened to consider. It is a personal question and, as it has been treated, is here passed.

The remainder of page 27, down to the middle of the page, is devoted to an inexact description of the Bates preferred project B. It is of no particular value to make corrections of features presented at length in the original report, so these, too, are passed.

After this description (middle of p. 28) comes the discussion of the Atlantic terminal harbor. This is an important matter, and it will be treated after the points on which no comment is necessary have been eliminated.

Following the discussion of the Atlantic harbor and breakwater (top of page 28) is a review of projects A at 27-foot level and B' at 97-foot level, and the record of the Board's disapproval. No issue shall be taken here and now with their conclusion. Various considerations (among them that this A is the only easily transformable canal and at some certain summit level it is as cheap as B) make this, the two-lock, terminal lake canal, project A, worthy of note. But as the Board attests, B was the project the speaker himself *qualifiedly*, as above noted, selected as furnishing the better canal. Here on the threshold consideration of the other is not given.

It is considered unnecessary to discuss the statement on page 30 that drowning the fever swamps under 27 to 62 feet of fresh water would not improve the sanitary condition of the Zone. The statement there is markedly questionable, and it is put forward as a *defense* of the sea level, not as a criticism of the lake canal. So it, too, is eliminated from consideration.

A final criticism to be eliminated from discussion is that on page 29:

"Mr. Bates has outlined no method and has apparently given no consideration to such procedures as would be required to transform his project B into a sea-level canal."

And pray, why should he? In preparing his project he has certainly not troubled himself about transforming to a sea level. He was seeking the very best and safest and most perfect canal he could devise. He is reproached because he did not supremely make procedures and estimates to transform his canal into what he considered a vastly inferior waterway. The whole Board having condemned project A, also condemns the whole idea of transformation and then register their disapproval that he did not include such provisions.

The fundamental law at the base of all justice is that a jury must be without self-interest, previous bias, or commitment. What can be said, therefore, of a body sitting upon such a world problem as that of the Panama Canal, seven of whom are passing judgment upon their own projects? That the issue was "predestinated" needs no further evidence than the Board's own criticism here (page 29).

Thus narrowed down, the engineering grounds on which the Board voted down project B are in all four propositions. After five months of study the combined bodies condensed into these paragraphs all the adverse judgments that they could collect. Since they voted unanimously "The Board disapproves the adoption of project B," the arraignment ought to be of some technical weight and conclusive. Turn first to the foot of page 28. Four paragraphs consider prices. The one specific impeachment relates to "excavation." The writer, as does every experienced executive, includes in this its corollary "embankment." He was and is under no obligation to use the unit prices or methods of estimating employed by others.

However, to illustrate the accuracy of the Board's "analysis," the following table is subjoined, taken from the details he gave (pp. 262-263, Board report).

The Board write (p. 20):

"The items of excavation given in his supplementary 'Graphic diagram of approximate quantities' appear to be less than those which the Board would estimate for the same purpose, but if the unit prices adopted by the Board be applied to the quantities for project B, as given by Mr. Bates, the total cost of excavation alone, after deducting the useful French work, will be \$85,289,500."

Excavation and embankment—project B.

[Table, pages 262-263.]

Section.	Quantity.	Price.	Amount.
40-foot contour to shore 600 feet wide	11,250,000	\$0.167	\$3,420,000
Shore to basin	2,500,000		
Basin to lock	20,600,000		
Dam, Gatun	1,000,000	.275	275,000
Pedro Miguel	1,000,000	.47	470,000
Mindí to Pedro Miguel	73,000,000	8186	59,750,000
Extra excavation (to cover lack of cross sections)			10,000,000
Panama Harbor	15,430,000	.22	3,394,000
Pedro Miguel to Sosa	9,400,000	.32	3,000,000
Old canal	1,000,000	.15	150,000
Chagres dam	2,000,000	.15	400,000
Do	1,000,000	1.00	1,000,000
La Boca dike	1,300,000	.30	390,000
Limon Bay	668,000	1.50	1,000,000
Naval basins	3,000,000	.16	480,000
Railway banks (Item VII)			60,000
Do			250,000
Miscellaneous (Item IX, page 163B)			980,000
Total			85,019,000

What further comment is necessary? Alone, unaided, paying his own staff, the writer's estimate is within this very trifle of that made by the Board with all the resources of the nation at command. In an estimate of over eighty-five million his figures receive here ample justification. Further on in this review the writer will present fur-

ther and convincing evidence of the baselessness of the other "comparisons" regarding dams and locks and quantities and prices to which the Board have subscribed.

"Inundated land values" is the next count.

The same criticism is repeated against the +85', which also submerges some of the higher agricultural land which has a certain value. B submerges almost exclusively terminal swamps. The 85' estimates for the outside value of their submerged land \$300,000. If theirs, inclusive of tillable areas, rates at but \$300,000, the Bates submergence must be materially lower. He considers that the benefits accruing to the Panama Republic from the covering of its pestilential morasses and the inland navigations of the new lakes would amply compensate for land values. There would be some parity adjustment, of course.

The Board finds Mr. Bates's estimate for his canal over low, and states that its construction will demand \$160,000,000. The cost would certainly mount to \$160,000,000 under the present management. Indeed, it would be vastly exceeded. When the speaker named this figure he named it not for a body of commissioners executing work under the system and with the order of intelligence and experience they employ. He was at the very greatest pains to announce this (pp. 160-161):

"This summary gives general estimates in regard to comparative cost. The writer is of the opinion that detailed estimates have little value unless based upon the contract system upon definitely selected plant and methods and upon a precise programme of execution and payment. It can not be too clearly realized that the unit costs of building structures, of making the excavations, and of distributing the spoil must and will vary greatly in the various projects and according to the means and methods employed and whether the contract or Government eight-hour-day work system be pursued.

"It is under the assumption of a contract system, with the greater economies and efficiency which it insures, and embodying his own experience in encountering hydraulic problems at home and abroad into his purposed means and methods that the writer makes for himself his schedule of unit prices and arrives at the table of costs.

"He submits that his plans can be best executed by an organization having an adequate capital which will enable the whole work, engineering and executive, to be responsibly undertaken under proper safeguards for the following definite sums per statute mile as and when completed, the canal reckoned as 40 miles from sea to sea, government, administration, sanitation, and policing costs not included."

Further, to the Board, he detailed the basis as follows (Board Report, pp. 261-262, items I to VII):

"The prices herein presented are based upon the following premises:

"I. A contract for the engineering execution of a definite project, with a proper programme of execution, with acceptable terms and times of payment, under suitable guaranties and proper inspection.

"II. Free right of way for all operations; exemption from taxes, dues, duties at the Isthmus, imports of United States Government, Republic of Panama, State or municipal charges of any kind.

"III. Free use and consumption for general purposes of all Gov-

ernment property, material, plant, etc., at the Isthmus, or purchased therefor.

"IV. The free use of Panama Railway and its property through a contract with the Government to execute its public service, to transport passengers, freight, mail, express matter, locally and across the Isthmus, for fixed prices per passenger and ton mile; to equip, extend, maintain, and operate the railway for the time of canal construction, the Government to take care of the bonds. All through rates of traffic agreements to be abrogated and a spot-cash system at the Isthmus substituted.

"V. The government of the Zone to have the care and expense of hospitals, sanitation, and policing, and regulation of the liquor traffic.

"VI. Contractors' employees to work and to be paid by the hour.

"VII. Reenforced concrete to be employed in structural designs, where practicable instead of masonry or solid concrete. Designs to be approved by Government."

He states as clearly as the English language can state anything that his estimates were not at all those which the canal under its Commissioners would require. They were those which he individually as a contractor would quote for the building of the waterway under his own methods. The test of all prices is on the finality, what men will contract and put down money to execute and deliver. He set his estimates up against that supreme, that final, that unchallengeable test. To its logic there is no argument; from its verdict there is no appeal. He rested the question of his canal's cost there, and on the canal finances as they were publicly supposed to exist in the summer of 1905. Since then "a river of money has run under the bridge." At least \$16,500,000, perchance much more, has gone into a "fixed investment," whose real value to any project is a fit subject for reflection. Commission methods and calculations include certain indulgences of expense which a contractor would expect to forego.

The writer did not reckon upon buying steamships for nearly 50 per cent more than their value, steam dredges, shovels, and locomotives, and a world of stuff before determining the type of canal or a programme of methods and execution. He did not reckon, for instance, upon some purchases reported to have been made by the Isthmian Canal Commission.

Serial No. 207, of April 15, 1905, bids for which were opened May 12, 1905, in class 12 a requisition for 104,000 pairs of butt hinges, and again in Serial No. 289, of November 20, 1905, bids for which were opened on December 8, 1905, we find in class 28 nearly 84,000 pairs more of the same article, making a total of 188,000 pairs. There were also purchased on open purchase requisition by the New York purchasing agent of the Canal Commission prior to April 15, 1905, about 60,000 more pairs of T butts and strap hinges.

One pair of hinges is all that is necessary to hang one door or window, so that provision is herein made for about 250,000 doors or windows. This is a devotion to the open door—to 250,000 of them!

Again, in Serial No. 289, as above mentioned, hinges were specified as "bronze plate on steel." The difference in cost between these and the plain steel for the quantity specified is approximately \$5,000. A costly open door!

In Serial No. 207, class 11, of the same dates as above, there are called for 117,500 steel set screws in quantities of 2,500 of each size from three-eighths to 1 inch in diameter, and also 130,000 hexagon cap screws in all sizes from one-fourth to 1 inch in diameter. Such a stock of set and cap screws could not be found in any factory or warehouse in this country. In fact, many of the sizes had to be made up specially. The writer does not employ a dozen on a \$250,000 dredge.

Just exactly what use there could be for such a quantity of this material it is hard to imagine, especially as there is very little machinery being built on the Isthmus.

In Serial No. 216 of April 19, bids for which were opened on May 17, 1905, we find specified in all 2 100 rail saw machines of the "Bryant" type. These are small machines, operated by hand power, using circular cold cutting saws. They are needed by section gangs and track layers. This number would allow two machines per mile on the Panama Railroad. The great railroad systems of the United States do not have ordinarily more than one machine of this type to every third section of 5 or 10 miles. The approximate cost of this class was \$10,000.

In the same Serial No. 216, in class No. 28, were specified 5,916 dozen files. These were of all kinds, including different shapes and cuts. They took in practically the entire file list from beginning to end. The quantities on the items specified were away out of proportion to commercial practice, as they ordered the same quantities of all lengths. Ordinarily where 100 dozen of 10, 12, and 14 inch files are specified 25 dozen of 4 and 6 inch are ordered and 10 dozen of 18-inch, and usually a larger quantity of 8-inch than any other. The enormous size of this requisition makes one wonder what unwonted office files are to serve on the Isthmus. It is safe to say that there is no manufacturing concern in the United States that could use this quantity annually.

In Serial No. 216, class No. 34, there were specified 19,000 pounds of various kinds of steam and water packing. With only a few steam shovels, a few locomotives, and a small number of stationary engines and boilers, this amount of packing was excessive. There was also purchased on August 17 2,500 pounds more of packing, as was called for in Serial No. 265 of August 7. Still another item was for thousands and thousands and then more thousands of handsaws 26 inches long.

The above are only a few purchases which show the extreme carelessness, or possibly lack of knowledge, with which these requisitions have been made, passed upon, and purchased. These items are merely in the line of supplies. It is probable that the machinery department will show up even more glaringly.

Further, in making his price the writer did not reckon on handing his fuel item over to other mercies or in negotiating with any country but the United States. Making now again his reserves, and believing nevertheless that there is a sure way out of this Cretan labyrinth, he turns to a more agreeable topic.

After disapproving "B" the Board naively observes that the difference between "B" and the Board's recommended 60-foot "is not great." "Such difference as exists is found chiefly in the more costly structures of Mr. Bates's project, such as the dam and spill-

way at Pedro Miguel and the works of the Obispo triangle and in the effective system of control of the Chagres flood." The difference between "B" and the majority's "60-foot" design is here categorically defined. It consists not in difference of principle or places or hazards or engineering perplexities, but in difference, they claim, of costs. This is the most important statement in the whole review, for it settles beyond controversy by the assertion of the Board itself that the inferiority of "B" over their 60-foot is as announced, viz:

1. Great cost of dam and spillway at Pedro Miguel.
2. Greater cost of the works at Obispo triangle.
3. Less effective control of two low dams which let the water run out than by one high dam which holds it imprisoned.

The cost of the dam and spillway at Pedro Miguel is given in his estimate (p. 262) at \$7,000,000. The cost of the concrete structure, etc., there, as given in the 85-foot estimates, is (p. 97) \$7,288,000. The Bates constructions are cheaper by \$288,000.

TERMINAL HARBORS.

The next judgment is, "His harbors are ambitious." He accepts the adjective with all that it includes for him and for them. Terminal facilities are an integral and indispensable feature to this waterway. They are as vital to it as its dams or its water courses. No ship can enter or leave the canal till right preparations are made to receive and to safeguard her.

The Spooner Act is explicit as to provisions and adequacy. Nature in the possibilities of the conformation at Panama had been propitious. The writer accepted her favoring lead and provided worthily for this world's canal.

The Bates harbors, with their combination of salt and fresh water, were unique and single, and unmatched in all the reaches of the globe. In size, availability, and serviceability to commerce they were the most perfect he could conceive. Further, his estimates provided and included them.

How do the others comply with the Spooner Act? What have they provided? Practically nothing at Panama. The International Board convened to settle, once and finally, all problems for Panama decide to not consider these at all. The minority does not so much as *locate* its Atlantic terminus. If it shall be at Colon, or at the lock site 8 miles away from Colon, or at some spot between, it does not deign to say. Yes, in comparison with what the Board considered necessary and in measure and degree to their creations, his harbors for the Panama Canal were indeed "ambitious."

The Board believes finally (see also last paragraph, p. 29) "that the proposed method of control of the Chagres by a number of small reservoirs at Gamboa and above that point on the river will be less effective and more expensive to maintain than that resulting from the construction of a single larger reservoir with a 180-foot masonry dam at Gamboa." What number of small reservoirs does "B" propose at Gamboa?

It proposes one undersluice dam at Gamboa and one undersluice dam at Alhajuela—two, each the same height as the Assuan, in Egypt. These and these alone are the constructions designed for the control of the upper Chagres, so these two dams are the sole elements

whatsoever which concern the Chagres under Project B. The criticism of the Board is therefore that two are "less effective and more expensive to maintain" than one single larger reservoir with a suitable dam at Gamboa.

How are two empty reservoirs with controlled outlets less effective for accommodating a flood than one full one, whose surface has to be "depressed?" What weatherwise formula will tell when to depress the high lake which they propose and show? This is a simple untechnical question of averaging risks. If any accident befalls their monumental Gamboa dam, they have no second guard, whereas to the normally empty first one at Gamboa Mr. Bates has as outer defense, in case of accident, a second normally empty one at Alhajuela. Now, which is probably the safer arrangement—two dams and a lake +62.5, or one great structure? Each man can estimate for himself. As to the expensiveness, the two low dams were figured at \$5,470,000, using high unit prices. The Board gives as the cost of its one Gamboa dam \$6,000,000, so the Board's own figures are against its statement regarding costs by \$530,000.

The writer entertains no doubt that any contractor would rather build his Alhajuela and Gamboa dams together for \$5,470,000 than their Gamboa dam for \$6,000,000, as the volume of concrete is far less if a concrete dam is adopted. This point the Board leaves open.

The second difference lies therefore in the more or less efficiency of two empty basins over one full one. We revert now to the four lines on page 29. We quote:

"It is the further judgment of the Board that the proposed designs for the dams, dikes, or barrages proposed to be constructed at La Boca, Mindi, Gatun, or Bohio do not show the incorporation of such features of construction as will give reasonable assurance of their stability or efficiency for the purpose contemplated, and that a proper provision of those features would greatly swell the costs indicated by Mr. Bates."

Here is a very vital challenge, one which, if founded in good faith and as a deliberate engineering judgment, would be a most serious consideration. What, then, can be said to this judgment pronounced by men who incorporate into their own designs the very same orders of dam and barrage, build them to two or three times the height, on the exact same foundations? Can such a procedure be justified in any way? "The dams or dikes at La Boca, Bohio, Mindi, and Gatun." There is no dam at Bohio in project B. As his text asserts, Mr. Bates after systematic discussion eliminated a dam at Bohio. At the other three sites the Bates designs are of the best Holland or Morrison type. Both are given on Pls. X and XI and in exact detail in Pls. VI and VII, the sheet piling being distinctly visible. Dams are not built without "preparing" the ground, and certainly no man whose money was guaranteeing a structure would be likely to fail to prepare the site in making ready. This preliminary work is noted and detailed in the estimate (p. 262). The stripping, so far as practicable, is done by hydraulic dredges, as is the writer's custom.

Now note. It is written that Mr. Bates's regular world-old Morrison design does not give assurance of stability. Well, does the entire integrity of the 85-foot canal rest at Gatun on a Morrison-type dam, whatever new name may be given it, with three times the

head which project B employs on the same site? If it is questionable for a height of 75 feet or 80 feet with a *net head* of but 29 feet, as advised for Gatun, why in the name of sanity is it recommended for a *135-foot dam* there holding back an 85-foot lake?

The minority has on the Panama side three dams of a similar character, with a maximum head of 65 feet and totaling over *2 1/4 miles*. (See plan.)

BARRAGES.

These of "B" are of the undersluice type, an existing instance of which is in visible operation at Assuan, in Egypt. The 85-foot incorporates here again the selfsame undersluice type at the selfsame Gatun. Mr. Bates's undersluice barrages are lower than all the others. He put in three dams of this order—at Gamboa, Alhajuela, and Cano—founding them in each case upon *rock*.

The sea level has put this same type dam at Gamboa for the discharge into the canal when the Chagres would be in flood, and an under-sluice barrage near Corozal to let "one-third" of it out. Four instances! So the criticism is certainly not justified from either majority or minority.

Let us see now, on the other hand, how the sea level carries the Chagres. It has diversions parallel to the canal on both sides and separated from it by artificial dikes or levees forming literally earth dams dozens of miles long, with the two new rivers higher than the canal waterway. There is no pretense made that these rushing streams are confined to their beds by rock fills equivalent to what is incorporated into the Morrison type. There is no disguise of the fact that this whole system of dikes is mostly founded upon erodable alluvium.

Both parties therefore are shown incontrovertibly to be using the identical dams under the identical conditions, but to be making them vastly more perilous and unsafe.

This, then, finishes the verdict upon "B."

BOARD'S +60 LOCK PROJECT.

We turn next to the lock project which the majority recommends. They write these words:

"This project (Bates's 'B') is less well adapted for transformation to a sea level than the lock plan with a summit level of 60 feet above mean tide, adopted by the Board for comparison, *although the difference between the two is not great.*"

Indeed, the writer would be startled at the similarity if he had not already analyzed its possibilities long before the Board was convened.

This, by a vote of 9 to 4, is denominated the best possible lock canal. It was substantially a sea-level vote. This is not the best lock plan, although it is better than the +85. A huge Gamboa dam lockage capacity, limited to the rain that falls above Bohio, more excavation below Bohio, 3 miles shorter lake, and 3 miles more of uncovered morass, no Panama reclamation, no Panama breakwaters or silt-protected entrance, etc. The writer recognizes the likeness, but sees no reason to indorse the decision that it is the best.

The outer Colon Harbor (p. 28) is here to be considered in connection with the subject of the costs. As a reason for rejecting the costs estimated by Mr. Bates, the following is given (p. 29):

"The extended examination which the Board has given to Mr. Bates's Project B fails to indicate that the work * * * can be completed for a sum much less than amount 50 per cent in excess of his estimate of \$134,000,000, including the additional cost of the outer breakwater at Limon Bay," etc.

Mr. Bates declined with emphasis to father the 27-year-old chimerical and extravagant project for breakwaters across the mouth of Limon Bay, which was resurrected by the engineering committee of the Walker Commission in January of last year. The recommendation of this committee, who also sign the majority report, was as follows (vide p. 294, Isthmian Canal Report of January 8, 1906):

"For these reasons the committee unanimously recommend that plans and specifications be at once prepared for a breakwater extending across the mouth of Limon Bay, approximately on the line drawn from the light on Toro Point to the Colon light. This breakwater will probably be designed in two parts, each about 4,000 feet long, with an opening between them 700 to 800 feet wide for the entrance of ships."

This plan the writer especially deprecates in his "System and projects," as follows (pp. 97, 98):

"Throwing two great arms across the mouth of the bay * * * is superficially an attractive project. Such breakwaters possess the advantage of making it easier and cheaper to dredge the approach, but it means the greatest ultimate expense, as stone spoil must either be hauled long, unnecessary distances or be quarried specially for the purpose. The latter must involve very great expense, as these breakwaters are founded in the deepest water and must be of much greater volume to resist the sea. The cheapest and best breakwater will be, as indicated, off Mindi Point, because it is founded in shallow water."

To the estimated cost of his project the writer declines to admit that of a breakwater rejected by all, superfluous to his plan.

SEA-LEVEL CRITICISM—TIDE LOCK AT PANAMA.

As premises, we quote Board report, majority, minority presumably assenting, as they do not disclaim their participation in the responsibility.

Board report (p. 56) reads:

"The question of the necessity of a tidal lock at the Panama end of the canal has been raised by engineers of repute, but the limited time available to the Board has not permitted the full consideration of this question which is desirable. It is probable that in the absence of a tidal lock the tidal currents during extreme spring oscillations would reach 5 miles per hour. While it might be possible to devise facilities which would permit ships of large size to enter or leave the canal during the existence of such currents, the Board has considered it advisable to contemplate and estimate for twin tidal locks near Sosa Hill, even though the period during which they would be needed would probably be confined to a part of each spring tide.

"The highest recently recorded range of spring tides which the Board has seen (September, 1905) was 19 feet 9 inches between extreme low and extreme high water, while from 1882 to 1887 the highest amplitude reported was 20.93 feet. With such tides for a brief period at dead low water there would be a differential head of about 10 feet—that is to say, the water in the canal would be 10 feet above that in the bay, while at extreme high water for a correspondingly short period the level of the water in the bay would be 10 feet higher than that in the canal.

"At the period of mean tide there would be no difference of level between the bay and the canal, so that during that period of the tide all the gates of the tidal lock could be open, leaving an unobstructed passage for vessels until the approach of the flood tide rendered it necessary for the gates to be closed until slack water would again be reached, and so on for each succeeding spring tide. During neap tides the range is so small that it will not be found necessary to bring the gates of the lock into use. Consequently throughout the neap period of each tidal cycle a continuously open and unobstructed passage for traffic will be provided through the tidal locks.

"If the matter be put into figures for the sake of comparison, it will appear (1) that in the project for the sea-level canal one lock may be required at times at the Panama end of the waterway. For one-half of each tidal cycle of fourteen days the gates may be operated to control a difference of head of an average height or depth of about 8 feet for short periods on each tide, while for the remainder the difference of level between canal and ocean will be negligible. For the remaining half of each tidal cycle the gates will be out of operation and the locks will present an open and unobstructed channel, and (2) that in the project for the lock canal six locks or even more will be required for a canal with a summit level 80 to 90 feet above the mean level of the sea; that these locks will have differences of level ranging from about 27 to 35 feet; that their operation will be perennial, they will always be required, and consequently that the menace which they will present to the safe navigation of the canal by large steamers can not be avoided and will be cumulative, i. e., must be multiplied by the number of lockages to which such vessels will be subjected during their passage through the canal."

This is supplemented by the leading expounder of the sea-level majority before the Senate committee, March 8, 1906.

"Q. Would not the same objection apply equally to a sea-level canal where you had to pass a lock gate to get into it?"

"A. No; it would not, Senator. One-half of the time the tidal gates would be wide open, and the ships would simply pass in as fast as they arrived, one after the other, and during the extreme tides, when the lock would have to be used, it would be a single lock, like the St. Marys Falls, but with only half of the lift of that lock—that is, assuming that the tidal lock must necessarily be there, and that is what we do assume. So that there could be no such congestion with a sea-level canal, and that is, to my mind, one of the most important elements of the whole question."

We have had a further "exposition" of this principle by a well-meaning author. The gentlemen are a bit misled; they are discussing the flow of water, evidently without experienced regard for the

conditions and safety of navigation. The canal is built for commerce to flow, not for water to flow.

Turn to the very example on which this argument is based.

Here is an official map of the Manchester Canal, obtained in Manchester from the canal corporation not sixty days ago. In the general description, on the upper center of this map, we read:

"The tidal portion from Eastham to Latchford locks (21 miles) is maintained at a minimum level of 14 feet 2 inches above Old Dock sill (or 9 feet 6 inches above ordnance datum—i. e., mean sea level)."

Please note the canal level is 9 feet 6 inches above mean sea level. The average high water of neaps is 11 feet 7 inches above mean sea level—i. e., 2 feet 1 inch above the canal level. The average high-spring tide is 18 feet 10 inches—i. e., 9 feet 4 inches above mean sea level (vide map, lower left corner).

Now, in order that the canal corporation should get a charter from Parliament, it had to agree to keep the lock gates open *at all stages* of neaps and springs above +9 feet 6 inches—the canal standard level; to close the gates at the moment of high water, and to allow the tidal prism thus impounded to escape (down to the canal's standard level, 9 feet 6 inches above mean sea level) through sluices, emptying into the upper reaches of the River Mersey.

The canal advocates fought tooth and nail to avoid the insertion of this provision in the act, but the Liverpool interests demanded it as the price of the bill, in order that this tidal volume might be utilized to increase the *scour* through the lower Mersey and its ocean bar.

The writer is familiar with that Manchester canal tide lock. He has watched the operation and discussed the situation with men in daily and hourly contact with it.

First. No water is allowed to *flow out* through the lock gates at ebb tide. All vessels lock out at the period of ebb tides, whether the water in the Mersey is above or below the canal datum (9 feet 6 inches above mean sea level). The gates are not open at the ebb.

Second. When the tide is coming in (is flooding)—whether neap or spring—and the gates are open, by force of or in compliance with the law, *no vessel ever essays to enter*.

It is too dangerous to enter a lock *with* the current. A lock can be safely entered only when there is slack water or an opposing current.

Just as in the Manchester, so in the Panama. No pilot will attempt, no owner will permit, no insurance company will insure a vessel to pass the tide locks *with* the tide, whether ebb or flood, spring or neap. Fancy a new Cunarder worth \$7,500,000 trying to go through a rock-lined passage *with* the current and with 6 feet of margin on either side. It is simply absurd. *Against* the current, yes; the vessel will steer. With the current, absolutely, no.

At the Manchester to-day, therefore, the transit capacity of the canal would be actually increased if that law was abrogated and if the lock *could* be used *all* the time.

A sea-level canal, therefore, with open gates "half the time" is a delusion. It would appear to be time that those "who go down to the sea in ships" and the Lloyds, who insure them, should have the voice which complacency has denied them.

CONCLUSIONS.

RELATIONS OF CULEBRA SECTION TO TRANSIT AND CAPACITY.

The influence of the section from Bas Obispo to Miraflores upon the time of transit and upon the capacity of the waterway to pass vessels depends on four things:

1. There must be a reception and turning basin at the north end of the constricted division.

2. There must be a similar provision at the south end.

3. There must be turn-out provisions, "gares," as they are called on the Suez. At first these can not be over 4 miles apart, but as the number of ships seeking passage increases, intermediate "gares" or *turn-out widenings* must be provided.

4. These relations depend on the length of the narrow rock-walled section, "200 feet wide on the bottom and 208 feet wide at the water line." In the sea-level plan this length is at least over 11 miles from below Bas Obispo to Miraflores. In the +85 and in project B the distance is 8 miles from the Obispo triangle to the reception basin above the Pedro Miguel lock.

Now it appears to have been assumed that all types and sizes of vessels can pass each other in the smooth rock-walled passage presented by the Board. It has been contended that when ships pass one will be tied up to the bank; then the other can pass safely. But this all depends on size. The writer submits that vessels over 65 feet in beam can not and will not be permitted to pass each other in this fashion. One or the other steamer will wait at the ends of the gorge until the way is clear against meeting any ship, and will then proceed, unless "gares" or widenings are provided.

Now these turn-outs ought not to be over an hour apart at the furthest—that is to say, 4 miles.

Consequently the sea-level scheme needs two intermediate turn-outs and two end basins or turn-outs besides. The projects of the writer and fortuitously the +85 of the minority have these end basins, and so require but one intermediate turn-out.

The majority and minority have again here omitted proper and absolutely necessary provisions of this character. Likewise their cost, which will be high, because the cut is deep, is not included. The Bates project gave a "gare" and arranged for its cost.

Even in a "gare" the most vigorous precautions must be taken to keep the waiting vessel in her position because of the *suction* of the passing vessel. If a large ship essays to pass another in the main channel, she is practically entering and leaving a lock, except for the time of lift. She must slow down, crawl at a snail's pace and then speed up, while the other has to stop, make fast, wait, cast off, and go ahead.

It is and always will be extra hazardous for large ships to pass each other in the main part of this narrow section.

Consider two vessels of 80-foot beam. They will be common enough in twenty years. Trace their procedure in getting past each other. One lies 10 feet away from the bank. Her side is 14 feet from the center, leaving 118 feet clearance for the other ship. Considering the tremendous displacement of water caused by a vessel of large dimensions moving 4 or 5 miles an hour and the suction set up, this clearance is not enough.

Therefore without "gares" the 11 miles of the Culebra section becomes equivalent, in time wasted in transit, to a *flight of three locks* like that of the minority at Gatun. The 8-mile Culebra section of the minority becomes, likewise, equivalent to two more locks than the six they have shown.

This is a navigation and canal capacity question. It is necessary to think sometimes, in a canal whose purpose is commerce, of the convenience and safety of ships.

Having reviewed the essential elements of the project for the Panama Canal, the time has come to weigh all in the final balance, not with a prejudice, but with an open-eyed justice. There are two designs which can profitably be compared with the Lindon Bates plan—the sea-level and the 85-foot scheme as evolved by the minority and Commission. Each represents the embodiment of the principles ruling their structure. The decisive question becomes here at the close, first, Wherein is the sea-level canal, as detailed by its latest official advocates, inferior? The answer will be summed up in the following category of defects and objections:

SEA-LEVEL SYSTEM.

Dimensions.—The canal approaches at either end are inferior and too narrow, and too shallow on Pacific end.

Channel.—Most bank length to be eroded.

Highest spoil banks.

Most cost to widen or deepen later when canal is in use.

Diversions certain to be silt clogged.

Dam and spillway system.—The Gamboa dam is a gigantic 180-foot masonry core earth structure very difficult to maintain during construction.

Great head of water up to 170 feet permanently impounded above canal.

Rock foundations not found suitable for core 180 feet high.

Disaster in case of cave in of, failure of Gamboa, Cano, and Gigante dams.

Problematic in construction and operation.

Most lower Chagres diversion work.

Excavation.—Highest cost of excavation.

Most plant.

Most excavation.

Least utilization of French excavations.

Greatest consumption of fuel in construction.

Most pumping during construction.

Greatest difficulties in distributing spoil.

Sanitation.—Least sanitary. Sanitation expenses not estimated, \$15,000,000 to \$20,000,000.

Swamps and disease foci all retained.

Most common labor and incident sickness and loss of life.

Navigation.—A constricted lakeless channel for the whole distance.

Greatest risk to vessels in transit.

"Northers" at Atlantic entrance, able to occasion detrimental currents.

Poorest harbor facilities.

Fewest turning basins.

Fewest passing stations.

Channel section areas not compensated to equalize currents.

Greatest curvature affecting navigation.
 Longest transit time.
 Least average speed.
 Pacific section too shallow and narrow, and reef obstructed.
Financial.—Greatest first cost, \$102,000,000 to \$150,000,000 more than the law of Congress admits.
 Greatest expense for interest and maintenance.
 Least net earnings.
 Highest deficits.
Legal.—Requires additional legislation to overrule fundamental provisions in canal law.

New appropriation needed to cover excessive cost.

Labor.—Most difficult to secure and hold labor.

Not one of these impeachments can be successfully met. The figure is now \$102,000,000 over the amount allowed and considered ample by Congress. Presumably the latest sea-level canal plan represents the best that can be evolved for it. On the facts incorporated into this the indictments stand.

The advantage of the sea level's *one* lock over a *two* or a *four* lock system is too dearly purchased at the cost of peril in each passage through its constricted, rock-flanked cuts; of the slower transit in its lakeless channel; of an extra expenditure of at least \$100,000,000; of the retardation of completion by at least seven years; of hosts sacrificed in the unnecessary excavation through marsh and hill.

+85 LAKE SYSTEM.

Dimensions.—Too small as planned on the Pacific end.

Channel.—Poorer facilities to deal with silt at upper end of lake.

No utilization of the canal cutting purchased by the Government in the section from Limon to Gatun.

Chagres swamps retained for 3 miles.

Dam and spillway system.—Gatun dam nearly three times necessary head—impracticable—of vast size.

Three others at Panama twice the necessary head.

Construction methods experimental and cost too great.

Locks obsolete before begun and too small, and there is no room for three in flight at Gatun.

Lockage.—Lockage supply capacity comparatively limited.

Excavation.—Excavation of very tough clay below 18 feet in Atlantic coast section; unhealthy and expensive; amid Chagres swamps.

Navigation.—Pacific terminal channel too small, and reef in course of vessels.

Less available and contiguous fresh and salt water harbors at either end.

Undue and detrimental currents at Obispo end of Lake Bohio.

Only one fresh-water naval station convenient to termini.

Fifty per cent longer transit line.

More lock leakage.

Sanitation.—Little inherent in plan during execution. Main marshes unsubmerged, disease foci retained, during all of construction; \$9,000,000 not estimated at all.

Financial.—Greater costs.

Greater yearly interest, operation, and maintenance costs

Legal.—Without nullifying or altering fundamental statute provisions in the Spooner Act the canal can not be built.

New appropriations needed.

Railway practically obliterated.

Safety.—Its dams and locks are unsafe. Its Atlantic and Pacific approach channels are obstructed or menaced by sunken reefs.

Cost.—The cost is underestimated by \$20,000,000 to \$25,000,000.

All of the above indictments and more stand against the 85-foot project of the minority and Commission. These disadvantages, also, are unanswerable, nor have the plans any saving features to redeem them.

COMPARISON OF PROJECTS A AND B.

Since the author's preferred designs furnish several applications of the principles advanced, it becomes concludingly in order to decide of these which will furnish the best canal. The concrete advantages of A over B are, detailed:

Project A.—It is the simpler and easiest to transform by adding to or diminishing the locks.

Its transit time is slightly shorter.

Has fewer locks.

Less diversions of Panama Railway.

No questions of cost and maintenance of the extra locks, dams, sluices, and Pedro Miguel Bypass.

Least care during operation.

Superiorities of project B over A are:

Project B.—Less expenditure.

Quicker to construct.

More sanitary because of third lake.

Less excavation in the central section.

Submergence of the low valley between Bohio and Obispo and all the various constructive and sanitary advantages attending the condition thus created.

Shortening of construction time by a year or more.

Lake Gatun takes better care of the local streams emptying into it than project A can provide.

The lake takes the place of the expanded channel of A from Obispo-Triangle northward.

Less bank length to be maintained as canal banks are submerged.

Less curvature affecting navigation.

More turning basins and natural passing places.

Less pumping during construction.

Lockage being practically the same, therefore, for the two projects A and B, and over 50,000,000 tons, the preponderance of advantage, unless it be decided that the level of A can be advisedly raised, lies with project B.

The level of A can, however, be raised to +35 by incorporating the tandem twin-lock system, and the difference as to cost between A at this level and B, as set forth, will be relatively small. But the advantage in cost remains still to B.

Therefore, that application of the author's system which is incorporated into project B is the one which were best adapted for the American canal.

(Therefore, after a short executive session, the committee adjourned until Monday, March 12, 1906, at 10.30 o'clock a. m.)

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Monday, March 12, 1906.

The committee met at 2 o'clock p. m. (no morning session having been held).

Present: Senators Millard (chairman), Kittredge, Dryden, Hopkins, Ankeny, Morgan, Taliaferro, and Simmons.

Present, also, Maj. Gen. George W. Davis, U. S. Army (retired).

STATEMENT OF LINDON W. BATES, ESQ.—Continued.

The CHAIRMAN. Mr. Bates, we are ready for you to proceed.

Mr. BATES. Mr. Chairman, I would say first that in looking over the text I find that there are a few errata, of no particular moment, which might be taken cognizance of when the final printing is made. I will say, further, that if it is desired to have this text represented in any way by the plates which I prepared to go with it, the stones (which I have in New York) are at the disposal of the Printing Office.

The CHAIRMAN. Thank you.

Senator KITTREDGE. Mr. Bates, on page 1683 of your statement I find the following:

"The writer did not reckon upon buying steamships for nearly 50 per cent more than their value, steam dredges," and so forth.

Have you any statement to make regarding that?

Mr. BATES. Yes, sir. If I am asked for an explanation of why I made that statement, I will make it.

Senator KITTREDGE. I wish you would.

Mr. BATES. When the *Havana* and the *Mexico* were bought, I made inquiries as to what those vessels had cost and what had been their construction history; and to the best of my information it is this: That when those vessels were to be built there were two prices bid—one by the New York Shipbuilding Company, if my informant is correct; the other by Messrs. Cramp. The first bid was \$550,000, and the bid for the ships by Messrs. Cramp was \$610,000. Those vessels were built in 1898 and 1899. They are, therefore, five or six years old.

It is the custom of the P. and O. Steamship Company, the greatest steamship company of England, to write off—

Senator KITTREDGE. What is the P. and O.?

Mr. BATES. The Peninsular and Oriental Steamship Company, which is the great company running to the Orient, from England to India, to China, Japan, etc. It is their custom to write off 7 per cent per

annum from their new ships; that is, the first year on the basis of 100 would be 7 per cent off; the next is 7 per cent off of the remainder, etc. Now, applying that principle in order to get at the value of these ships, you will find that the real value of those ships was somewhere about \$450,000; and at the time that they were bought they were insured for about that price.

Senator KITTREDGE. What price?

Mr. BATES. Four hundred and fifty thousand dollars. It has been stated that the Ward Line carried some of their own insurance; but I would say, in regard to the point of insurance, that you insure a vessel for two things, usually, what we call "particular average;" that is, in the event your vessel is damaged, that you shall receive enough to make good that damage. Then we also take out a "total-loss" policy, which represents the value of that ship to us as a commercial opportunity, and that may be what the underwriters are willing to make.

For instance, when I insure a dredge going to Australia, I insure for particular average, we will say, at \$250,000 (£40,000), but as against total loss and any prospective profits, etc., perhaps £10,000 or £15,000 more. So that the value of a ship is not the sum of the total loss and the particular average. The real value of the ship is represented by, in a measure, its insurance for particular average—quite a different thing.

I consider that those ships, at the time that they were purchased, were worth, together, about \$900,000, and no more; and when you add 50 per cent to that, you get the price that was paid.

Senator KITTREDGE. Do you base that statement upon facts within your own knowledge or upon information that you have received?

Mr. BATES. The facts within my own knowledge relate to the writing off, etc. The prices that I have mentioned came from an estimator, who was, he claimed, cognizant of the prices which those vessels were bid at when they were originally contemplated for construction.

Senator KITTREDGE. Who gave you the information?

Mr. BATES. It was a Mr. Langell.

Senator KITTREDGE. Where does he live?

Mr. BATES. He lives in Camden, I think, New Jersey. At any rate, he is an employee of the New York Shipbuilding Company.

Senator KITTREDGE. And can you give us any better address than that?

Mr. BATES. No; that will certainly reach him.

Senator SIMMONS. Have you his initials in your mind, Mr. Bates?

Mr. BATES. No, I have not; but I can very easily get them.

Senator KITTREDGE. What is your understanding of what is covered by the original cost of construction? Does that include the furnishings of the ship?

Mr. BATES. It usually does. I bought all my ships in England, including all of the furnishings. Some people do that, and other people provide their own crockery, linen, etc. In my case, in building half a dozen ships at Armstrongs', they supplied everything; and when we went out for a trial trip we went right away on a voyage of 14,000 miles.

Senator KITTREDGE. That depends upon the contract price, does it not?

Mr. BATES. I think so; yes, sir.

Senator KITTREDGE. Do the prices that were given you include the original cost of the ship, or do they include furnishings, as you understand?

Mr. BATES. It would include, I should take it, all, perhaps, except the crockery and linen. If you mean by "furnishings" the chairs, sofas, and everything of that sort, they would all be included in the contract price.

Senator KITTREDGE. What I am getting at is, when you speak of the price of the ship I want to know whether that means the cost of it as it leaves the stocks or when it is ready for a voyage?

Mr. BATES. When it is ready for the voyage or the trial trip, usually. In my case I have always had it absolutely complete; and the shipbuilding yards of the Armstrongs and other yards with which I have built have been great assembling establishments, who furnished everything.

Senator KITTREDGE. Did you receive information of this character upon this subject from any other person than the gentleman named?

Mr. BATES. No, sir.

Senator KITTREDGE. With what company was he connected? I have for the moment forgotten.

Mr. BATES. He is now connected with the New York Shipbuilding Company, at Camden.

Senator KITTREDGE. Is that company in any way a competitor of the company of whom these ships were purchased?

Mr. BATES. I think it is; but, on the other hand, this man had not, I think, at that time, entered the employ of this company.

Senator KITTREDGE. When was the information given you?

Mr. BATES. About the time of the purchase of the ships; last summer some time, as I recall it.

Senator KITTREDGE. What was his business at that time?

Mr. BATES. He had been with the United States Shipbuilding Company, that became bankrupt, and with Harlan & Hollingsworth.

Senator KITTREDGE. In what capacity?

Mr. BATES. The same capacity, as an estimator. He is the man who makes up the figures on which bids are based.

Senator KITTREDGE. That is, for the building of the ship?

Mr. BATES. Yes, sir.

Senator KITTREDGE. Going back to the subject of which you were talking generally on Saturday, from what source did you secure the data to give us the testimony evidenced by your statement?

Senator DRYDEN. Senator Kittredge, before he leaves this point may I ask a question?

Senator KITTREDGE. Certainly, sir.

Senator DRYDEN. Can you tell for what amounts the marine insurance companies had insured these ships at the time they were purchased by our Government, when they were in the possession of the former owners?

Mr. BATES. I made inquiry as to that of one of the firms in New York and was told that it was about \$450,000.

Senator DRYDEN. And do you know whether the marine insurance companies had insured them for what they then considered their full value, or was it only a partial insurance?

Mr. BATES. I assumed that that was insurance for particular average.

Senator DRYDEN. You do not know in what marine companies they were insured?

Mr. BATES. No, sir.

Senator DRYDEN. That is all.

Senator KITTREDGE. Have you in mind the question I asked you?

(At the request of Mr. Bates the question was read aloud to him by the stenographer, as follows:)

"Going back to the subject of which you were talking generally on Saturday, from what source did you secure the data to give us the testimony evidenced by your statement?"

Mr. BATES. Do you mean the technical data?

Senator KITTREDGE. Yes.

Mr. BATES. In the first place, I had the report of the advisory board complete. In the next place, I had my own experience and my office data. In the next place, I had as much of the French data as I have been able to accumulate. I presume that I have some forty or fifty books, giving a concise, accurate history of the Panama enterprise from the date of the inception until this time.

Senator KITTREDGE. Have you ever been on the Isthmus?

Mr. BATES. Yes, sir.

Senator KITTREDGE. When?

Mr. BATES. I was on the Isthmus in August, 1904. I left New York, as I recall, about the 26th of July and returned in the latter part of August.

Senator KITTREDGE. Is that the only visit to the Isthmus you have ever made?

Mr. BATES. Yes, sir.

Senator KITTREDGE. Did you make any explorations at that time?

Mr. BATES. Yes, sir.

Senator KITTREDGE. Of what character?

Mr. BATES. I think I can point out on the map there so that you can appreciate just what I did. In the first place, I had, prior to going down to the Isthmus, a desire to take contracts, and I had had before the old Walker Commission at its very first meeting a proposition to fill Colon, raising it above grade, using one of my great dredges in Australia, which at that time was idle. Nothing came of it at that time, but with the consent or the approval, I should say, of Admiral Walker, I went on the same ship with some of the members of the Commission going to the Isthmus at that time, with a view of ascertaining the local conditions, and when we arrived there I carefully examined Colon.

Senator KITTREDGE. In what way did you carefully examine it?

Mr. BATES. I walked all over it. Then I walked away up around here and around to the dry docks on this side, and in a boat went clear up to the canal here as far as the deposits which had been made there by the Chagres, which is about Mindi. Then, another day I went up to Gatun and down this old channel and then back through to Colon, and another time I took a boat at Bas Obispo and went down the river all the way to Gatun. Another day I went all around Panama, Sosa Hill, and this country in here on foot. On another occasion I took a boat and went up the Rio Grande at low tide, going as far as Miraflores, and then, leaving the boat there and having gone through and gone up as far as I could go at low tide, I walked all the way to Bas Obispo.

Senator KITTREDGE. Along the route of the old French line?

Mr. BATES. Along the route of the old French line; and another time when I was there I went over the railway route on both sides of the Culebra cut.

Senator KITTREDGE. That trip, the trip on the railroad, was——

Mr. BATES. That was on foot.

Senator KITTREDGE. Oh, you walked on the railroad?

Mr. BATES. Yes, sir.

Senator KITTREDGE. You did not ride on it?

Mr. BATES. No, sir. Then I went around on the dump trains here, and I watched the old French excavators, etc.—things with which I was familiar. Then I went down to Colon. I would say that I have had a very great deal of practice in observing the topography of water-courses for twenty-five years.

Senator KITTREDGE. Did you go up the Chagres toward Alajuela?

Mr. BATES. No, sir.

Senator KITTREDGE. How far east of Gamboa did you go on that trip?

Mr. BATES. Nowhere east. I was at Bas Obispo, just where I could see the Gamboa site.

Senator KITTREDGE. Did you go up to the site?

Mr. BATES. No, sir; I was on the other side of the river.

Senator KITTREDGE. Did you make any examinations by way of borings to ascertain the character of the material or the foundational conditions for any of the structures you have recommended to us?

Mr. BATES. At Sosa Hill I did not take borings, but I observed very carefully the geology in respect to it, looked up the old French data in regard to borings such as I could get hold of, and I had——

Senator KITTREDGE. Where did you find such data?

Mr. BATES. Some of it at the office of the Isthmian Commission—very little of it; but most of it in the old French records of the liquidators, and in the reports of the geologists, and in the geological profiles across the Isthmus.

Senator KITTREDGE. Printed reports?

Mr. BATES. Yes, sir.

Senator KITTREDGE. Public reports?

Mr. BATES. I have them here. Then I had a Mr. Dougherty, who was one of the finest mining engineers of my acquaintance, reexamine the Ancon, Sosa, and La Boca sites on his way down to South America; and in that connection he spent some time around Panama.

Senator KITTREDGE. How much time?

Mr. BATES. He was there about a week waiting for a steamer, and sent photographs and a special report upon what he considered to be the formation, which confirmed my own view; and I find that the borings which have later been ordered by the Commission show that these sites, which, when I first mentioned them last year, were all said to be mud, really had rock as close, if not closer, to the surface than any other sites for dams and locks on the whole Isthmus, except at Alhajuela.

At Mindi I looked up very carefully the old data of the French, and I observed this Jaramillo Hill and the first cutting which was made by the French when they were digging the canal past that point.

Senator KITTREDGE. To what extent did you have access to the data of the French relative to the Mindi location of a dam which you propose on one of your plans?

Mr. BATES. I had the maps, the profiles, the photographs, and I had seen the location. I was there when the borings were being made which are on one of the maps which I have here.

Senator KITTRIDGE. At Mindi?

Mr. BATES. At Mindi and out into the bay, out here [indicating]. There was a boring foreman there who had been on the Nicaragua Canal, and he had charge of the boring party, and he was boring at the time I was there with reference to the new alignment destined to go out into Limon Bay instead of the old line. I got from him this sample that I had on Saturday, and I also got——

Senator KITTRIDGE. A sample of clay?

Mr. BATES. A sample of what I should call a clay rock; and I would say that that clay rock, to my mind, approaches as nearly a brick, a half-burned brick, a gray brick, as anything else. I tried yesterday to get a sample that would look like it. I think that the best name for that is really "clay rock."

Senator KITTRIDGE. The point I am getting at, is to what extent did you make personal investigations independent of the records of what the French engineers did and of what the Walker Commission and the later Commission and Engineer Wallace did?

Mr. BATES. Those are practically the result of my own observations.

Senator KITTRIDGE. Is it observation or is it exploration?

Mr. BATES. It is close observation of what was going on.

Senator KITTRIDGE. Had you any instruments there yourself?

Mr. BATES. No, sir.

Senator KITTRIDGE. Had you any assistants?

Mr. BATES. My son was with me.

Senator KITTRIDGE. You made no measurements, no borings?

Mr. BATES. I took the records that were official as being correct; and I had every reason, from my observations, to believe that they were accurately taken.

Senator KITTRIDGE. Do I understand that the information that you have given us here is the result of an examination of records made by the French engineers?

Mr. BATES. Made by both the French and the Americans.

Senator KITTRIDGE. I was about to add, the engineers of the old Walker Commission and of the new Canal Commission.

Mr. BATES. Yes, sir.

Senator KITTRIDGE. Under Mr. Wallace's direction?

Mr. BATES. Yes, sir.

Senator KITTRIDGE. That is right, is it?

Mr. BATES. Every mortal thing that I could get.

Senator KITTRIDGE. Is your information based upon any other facts than such as are disclosed from an examination of those records?

Mr. BATES. In several particulars that would have to be qualified. I have Mr. Dougherty's report here.

Senator KITTRIDGE. To what extent did Dougherty make that examination?

Mr. BATES. He made it just as any geologist and mining engineer does, by observing the wells and the character of the rock and making use of his knowledge, just as a man does when he is an expert in a mine.

Senator KITTRIDGE. How can he determine the character of the rock?

Mr. BATES. The rock comes to the surface.

Senator KITTREDGE. He can where it comes to the surface; but it does not come to the surface between Sosa Hill and La Boca, does it?

Mr. BATES. No; it does not, I think.

Senator KITTREDGE. Or between Sosa Hill and Ancon Hill, at all points?

Mr. BATES. No; not at all points.

Senator KITTREDGE. Nor does it come to the surface at all points from Ancon Hill to Corozal Hill, does it?

Mr. BATES. No; it does not come to the surface, and of course a man can not see into the ground.

Senator KITTREDGE. I am getting at this point: To what extent did he make an observation? How does he know the character of the rock except as it appears at the surface? Has he any other source of information?

Mr. BATES. There is no other source than what you get by borings and what you can see.

Senator KITTREDGE. Yes; and from the records made by the French engineers and the other engineers whom I have mentioned; that is right, is it not?

Mr. BATES. Yes, sir; that is right.

Senator TALIAFERRO. French and American engineers?

Mr. BATES. Yes, sir.

I have mentioned Mr. Dougherty. I will say that on the site of the La Boca dam I had misgivings; but the man who built or had to do with the building of the piers happened to come into my acquaintance, and he it was who acquainted me with the depth at which rock had been found off the La Boca pier.

Senator KITTREDGE. Who was that?

Mr. BATES. I think the man's name was York, but I can not recall at the moment for a certainty. Then Mr. Paine, of the Railway Age, gave me same data in regard to this section of the Chagres.

Senator KITTREDGE. From what source did he get his information?

Mr. BATES. He had it from personal observation. He probably has done more explorations off the line of the canal than anybody else that I have met on the Isthmus. He was one of the associate editors of the Railway Age.

Then, at the time that the great rush to California was going on, there were several books written in regard to this country between the Chagres and there [indicating]. I happened to have those books, and they were rather vivid in their description of the way the spurs ran down into this valley, and that it was a narrow valley, and the party who wrote this book in particular was one who started for California with a camel train, landed his camels at the old town of Chagres, and endeavored to take them to Gatun by land; and he writes very vigorously of his experiences, and speaks of these spurs and the slipperiness of the clay in this country here [indicating].

Then I happened to have, also, a work written by Captain Peacock prior to 1879, or just at 1879, and addressed to De Lesseps before the Congress. Peacock was a man after the order of Captain Cook—an official British surveyor. He landed in 1831 in this little bay here, which he named on his plans Peacock Bay; and then he writes this book, giving his journal across here to Panama for the route of a canal. I was attracted particularly by the fact that he said he had gone on

foot from this bay to Gatun, and that the way was comparatively level; but of course it is a jungle, and a man may go up 50 or 100 feet without knowing it. At that time this bay in here had 4 fathoms of water—24 feet—and now it has but 6 or 8.

Senator HOPKINS. Whereabouts was it that he had the 24 feet of water?

Mr. BATES. Right in this little bay here—right there [indicating].

Senator HOPKINS. And now it has but how many?

Mr. BATES. Six or 8 feet. This point is called Kenny's Bluff now, but in his records he calls it Point Peacock. He made surveys practically all over the world, and he locates the line of his canal from Gatun right to this bay and makes his terminus there.

Senator DRYDEN. What has caused that decrease in the depth of the water?

Mr. BATES. I think, sir, that it has been caused by the Chagres River going down the French canal and emptying into this bay at Mindi, instead of going down its old route to this point here [indicating].

Senator HOPKINS. Mr. Bates, I want to ask you a few questions about the point there at Gatun.

Mr. BATES. Yes, sir.

Senator HOPKINS. You stated the other day, if I understood you correctly, that a Morrison type of a dam could be built there?

Mr. BATES. Yes, sir.

Senator HOPKINS. I wish you would explain that in detail.

Mr. BATES. Yes. Now, let me get one of my maps right here. This profile here gives the Gatun site with a Morrison type of dam. I call it the Morrison type because Mr. Morrison was its most prominent advocate. It consists essentially of making an earth fill between two rock fills. The first thing that you would do would be to put in your two rock ends of the dam on either side, and then fill in with earth.

Senator KITTREDGE. You would construct it in what way for the rock?

Mr. BATES. The rock may be put in what we call *pierre perdue*—that is, it is thrown in roughly. Of course the first thing that you do with every dam site is to clear off all the vegetation; and if there is any bad material which should not be there, you remove that also, down to what is sufficiently dense, according to the plans.

Assuming that to be done, then you have your rock fills on either side and your earth fill between. Now, then, that earth fill between may be put in in a number of different ways. It may be put in by train or it may be put in by a hydraulic dredge. When it is put in by train it has to be rammed very carefully, put in in horizontal layers, all vegetation carefully excluded, and thoroughly wet down and water-packed, as we call it. When it is put in by a hydraulic dredge the stream of water is the vehicle for the transmission of the material that you put in. It packs hard, just like a sand beach, like the hard beaches in Florida; so that if the material that you are putting in is sand, you can walk over it within a few moments after it is put in. If, however, it is of a muddy, clayey character it sometimes takes days and weeks to sufficiently drain out; and in some cases I have been obliged, in making reclamations, to tile the ground just as you would in a swamp, so as to drain the water through these tiles. Sometimes we put in the tiles beforehand. If you do not do that it

is likely to form a crust; this crust may be 2 or 3 feet thick, and underneath is a perfect jelly. Certain materials drain naturally.

At Galveston, for instance, I am putting in just about half of what is required in this Gatun dam. There the material is a light sand, and it drains off in a little while after we shut off the water. If, however, that material that we were handling was clay, it would not dry out for weeks and months.

Senator HOPKINS. Mr. Bates, have you made an investigation sufficiently exhaustive so that you could know whether or not there are any underground currents that would interfere with the placing of a Morrison type of dam there at Gatun?

Mr. BATES. Personally, I have not; but I have observed such boring information as has been obtained by, especially, the American Commission; and my judgment is that there is no reason at all why a Morrison type of dam with a low head is not perfectly feasible. With a high head I consider that it would become increasingly problematical as you get above 40 feet. Under that you are perfectly safe.

Senator HOPKINS. What do you say about your ability to establish a dam at Bohio?

Mr. BATES. I consider that it is perfectly feasible to put in that type of dam at Bohio; but my objections to it are simply these: that for the ultimate greatest capacity of a lock canal you want all the run-off that falls on the Isthmus.

Senator HOPKINS. Yes.

Mr. BATES. And if you put your dam at Bohio, you lose 43 per cent of your possible lockage capacity.

Senator HOPKINS. Yes.

Mr. BATES. And you can not get it.

Senator KITTREDGE. Bohio is, so far as site and conditions are concerned, just as favorable as Gatun, except the feature that you have just mentioned?

Mr. BATES. It has this advantage, that the dam is not so long. It has this disadvantage, that the ground is probably more porous under Bohio than it is at Gatun. The reason is that Gatun is nearer to the sea, and as the hills have been carried to the sea by the river the heavy stuff has deposited first, and at Gatun you naturally get a finer and a denser material than you would get at Bohio.

Senator KITTREDGE. Answering my question directly, if you will, Is Bohio just as favorable a site upon which to establish a dam for a lock canal as Gatun?

Mr. BATES. I think so, for practical purposes; yes, sir.

Senator HOPKINS. But, getting back to the point, you say at Gatun the soil is more dense and resists the seepage of water more than it would at Bohio?

Mr. BATES. I think so. That would simply mean that you would not need to have as great a distance between your rock fills, relatively.

Senator HOPKINS. Now, I wish you would explain that. The reason I am asking you this question is that there is some contention by some people who have examined those two sites to the effect that the character of the soil there at Gatun is such that you can not place a dam there that will stand; that the seepage of water is such that it will gradually destroy the effect of a dam at that point.

Mr. BATES. In answering that, may I use a practical illustration?

Senator HOPKINS. Anything that you wish.

Mr. BATES. On the Elbe-Trave Canal—you know northern Germany is a sand country—there was a section of canal there right through the sand plain, and everyone thought that a canal carried between embankments there could not be operated; that the sand would let the water all out. That did not turn out to be the case. What happened was that all the voids between the grains of sand filled with the fine silt that dropped after the water was turned into the canal.

Now, if at Bohio you have a coarser formation, then I would make the water travel a greater distance than it would have to if the material was more dense. That becomes a matter of engineering judgment; and if you find that there is more percolation than you would like you can always widen the dam.

Senator HOPKINS. If there is percolation there, you think there is no trouble in stopping it, if you make investigations so as to know the character of that percolation?

Mr. BATES. Yes.

Senator HOPKINS. And its extent?

Mr. BATES. Yes; but with this reservation—that in that tropical, earthquake country I would not subject that formation to a head of over 40 feet anywhere.

Senator HOPKINS. Yes.

Senator MORGAN. Why?

Mr. BATES. Because I think that you are coming to the point of balance where, if your dam should, by any reason, fail from an earthquake, you would have the greatest possible difficulty in putting it back. I have tried to make plain in my statement that it is very expensive to put back great dams by train service; but if you can put them back by dredge service it can be done with reasonable economy and quickly.

The limit that I have been able to put material with a dredge was probably at Portland, Oreg., where I made a damlike embankment about 32 or 33 feet high, and the greatest distance from the river was 2,800 feet. I have always felt that in that case I got to the limit of what I could do with this tool for doing this class of work which I had myself evolved.

Senator MORGAN. A dam 80 feet high, if it was broad enough, would resist the pressure quite as well as or better than one 40 feet high but not quite so broad, would it not?

Mr. BATES. It is not a question, sir, of resisting the pressure that makes these great widths for these dams. It is to limit the amount of percolation that you make it wide. If you have a head of 40 feet and a head of 80 feet you do not, with the smaller head, have to have your dam but half as wide, sir; and you find that illustration, sir, right here.

I had considered that in order to get the full lockage supply of the dams with a two-lock canal, one must have a dam and lock at either Mindi or Gatun, and at no other places. If, then, you have a four-lock canal, you must have it at Mindi and Gatun, and there are no other places; otherwise you will have the locks in flight, which I do not believe in.

You will see here a dam at Gatun exactly on the same axis as it is in the project of the minority here. On this side we have 62 feet, we will say, of water. On that side [indicating] we have 33; so that the net head is but 29 feet. When you have 29 feet you do not need to have so wide a dam. The result of having that head of 29 feet is

that in this dam, for the same amount of percolation, using the same formula, I have 4,500,000 yards, while in this dam you have 21,000,000. That is the difference.

Following up the question of the dams, we have here at Mindi—

Senator HOPKINS. Does that dam of yours stop all percolation?

Mr. BATES. With just the same formula as that one exactly.

Senator HOPKINS. Just leave that other one out. What is your judgment of yours?

Mr. BATES. My judgment of this is that it is perfectly safe, and that I could put it in easily, and I will show you why.

With mine I will put my first dam at Mindi. Then, when I am making this basin here I can pump my material direct, because it is within the power of my dredge to do it. I have the rock, plenty of rock, in Culebra, and this country from Jaramillo Hill to that point is full of these little hillocks. You see them here [indicating]. There are nine of them that come up above the top of the dam in that little distance there of about 3,000 feet. And so it is the simplest thing in the world. I could put in that dam in six months.

In the same way, the dam across the Chagres, in here at the mouth of the Indio—Mr. Maltby, in making the survey that the advisory board desired, found that it was about 3,000 feet across; less than 3,000 feet, his report says. No borings were ever made there; none have ever been made below Gatun in that distance, which is some 4 miles. No one knows whether that geologic gorge runs down there or whether it is a later uplift. But in any event the material deposited there must be of the same character as it is at Gatun, only finer.

When you come to the dry dock at Mindi—

Senator HOPKINS. When you say that "it must be of the same character, only finer," give us your reasons for making that statement.

Mr. BATES. Because the water first deposits the coarse material, and then finer, finer, finer, toward the sea.

Senator HOPKINS. Toward the sea?

Mr. BATES. Yes, sir.

Senator HOPKINS. What is the character of the material that you find at Gatun, and to what depths have you gone down?

Mr. BATES. We have the official profiles, which show—here is Gatun Hill, where the railway station is; there is a gorge which comes down across this way, in which the maximum depth recorded is 208 feet.

Senator HOPKINS. Two hundred and eight feet?

Mr. BATES. Two hundred and eight feet. On this side of the island they find another gorge which is 258 feet deep. My belief is that at Mindi there is no such gorge, and that you will find the rock all the way across there, probably about 60 feet and probably even closer to the surface.

Senator HOPKINS. Then, at Gatun you would have to go down 208 feet on one side and 258 on the other? Is that right?

Mr. BATES. No. In making this Morrison type of dam you first clear off the ground, taking off by dredges any of the very soft stuff that may be there. Then you get in your rock fill, and you fill in between with your earth fill, or, if you please, you first put in your puddle and your sheet piling, as they did at Assuit, in Egypt.

Senator HOPKINS. How far down do you go before you go to doing that—200 feet or 208 feet?

Mr. BATES. No; you probably would not go down; you would clear off perhaps the upper 10 or 15 or 20 feet, just according to the class of material you encountered.

Senator HOPKINS. Why would you not go down the 208 feet at one point and 258 feet at the other? Why would you not do that? That is what I want to get at; I want to learn.

Mr. BATES. Because you could not, Senator.

Senator HOPKINS. Now, if you could not go there——

Senator KITTREDGE. Why not?

Senator HOPKINS. Just let me finish, please.

Senator KITTREDGE. I beg your pardon.

Senator HOPKINS. You say you could not go there; but if you could not, why would you build on that location?

Mr. BATES. Because I am using a type of dam which does not need to go down there.

Senator HOPKINS. That is what I want to get at. Now, explain why it does not need to go down there.

Mr. BATES. We find that with a certain head of water you have a certain amount of percolation, according to the distance that you make that water travel underground and according to the character of material through which it travels.

Senator HOPKINS. Yes.

Mr. BATES. Now, then, applying the sum of human knowledge and experience on that subject, it results in a certain formula known as the Hazen formula, and that gives you the distance between the water on one side of the dam and the water on the other side of the dam; and when you have applied that it gives you the dimensions of your dam. People are a little in disagreement as to just the coefficients and other things to use in that formula; but substantially the right thing to do is to put enough there and enough width so that there will be a minimum of percolation and not more than you can admit.

Senator HOPKINS. Where does this percolation take place; at the top, or does it take place all the way down, 208 feet at one point and 258 at the other?

Mr. BATES. At Gatun it would not come through the dam, because that would be so thoroughly puddled that it would not come through the dam part at all.

Senator HOPKINS. Yes.

Mr. BATES. We do not know whether there are pockets of sand or porous material sufficiently well by any borings that may be taken to say whether any water, practically, would come through the first 100 or 150 feet. All the borings, practically, indicate that there would be very little, if any, percolation until you get down to where the coarser material is encountered in the bottom of the gorge. The consequence is that the water in getting to this side has to go down a certain depth, perhaps 50, 60, or 100 feet, perhaps even 200 feet, and then under the dam, and come up through that blanket on the other side; and I do not think it would come up. I think a certain amount might come; and the more head there is the more will come. There is the more danger of its coming.

Senator KITTREDGE. What about a dam 135 feet in height, speaking directly of the minority plan? What will happen in that event?

Mr. BATES. In the type of dam that Mr. Morrison advocated you would not make it as high as 135 feet. The minority have built a dam

of this shape, you see; it is 100 feet wide on top, and that summit is at 135 feet above the sea. The lake on this side is 85 feet above, so that you have 50 feet of height in here, as they say, of material taken from Culebra and hoisted up to this height, right on the front of the dam. In my judgment it does not add anything to the water tightness, because if it is tight already and thoroughly puddled you can not make it at all any tighter by any weight you put on it; but I should imagine that if you carried such an overloading to extremity—if, for instance, that was all lead, for an illustration—then you might get so great a weight on this portion that there would be subsidence here and uplift there [indicating].

Senator KITTREDGE. When you say “here” and “there,” kindly indicate by language where “here” and “there” means.

Mr. BATES. Yes; there would be subsidence in the crest of the dam and uplift on either side of the dam.

Senator HOPKINS. You mean the water would rise up? Is that what you mean?

Mr. BATES. Yes, sir. To give a practical illustration: In passing Lake Colville, on the Northern Pacific, we had a lake shaped like my hand, and ran across a little arm which was apparently solid ground. When we put in material by trains, it constantly went out and we did not know where it went to. But after we had been working there several months there came up an island about 1,000 feet out in the lake; and the trains to-day run across that place on a “U,” unless they have changed the line since I knew it—that is, the train is here and the island is there, and they are in equilibrium.

So that if you overload the crest of the dam you do not, I believe, increase the water-tightness, but you increase the possibility of subsidence or of slide.

Senator KITTREDGE. Then what would happen?

Mr. BATES. If it slid, your dam would go out.

Senator KITTREDGE. To what extent would the sliding occur before the dam would go out?

Mr. BATES. Just as soon as your water overtook it, you could not stop it. Then it would carry the earth and the rock and everything away.

I have seen the Mississippi scour away its bed 100 feet below its normal bed when it got started in a certain direction. When I was building the Puyallup Dam (which I have right here), it was the first dam, as I said, ever built by the hydraulic process in the world. We had there a tide of 18 feet, and the length of the dam was 900 feet. I put my dredge above the dam, where I could borrow the material and pump direct, and undertook to close it at the slack of the tide at high tide. The first time that I tried it I could not get it high enough during that tide, starting at the low tide and following it up to the high tide, to keep the water from overtopping, and it overtopped it and in five minutes it had a crevasse there 100 feet wide and 60 feet deep. I was standing on the dam at the time it happened and had to run for my life. So that when a dam breaks it goes almost instantaneously, and if there should be a fissure or break here the water would come through and it would scour.

Senator HOPKINS. You mean a break at the crest of the dam?

Mr. BATES. Yes; from fissure or subsidence. The water would come through—

Senator HOPKINS. What do you mean by subsidence?

Mr. BATES. Like a landslide on a railroad bank. Suppose a section right in here should go out by going down.

Senator HOPKINS. That is, suppose the section of the top of the dam should go out?

Mr. BATES. Yes; go down. For instance, it is now at a slope of 3 to 1.

Senator HOPKINS. Yes.

Mr. BATES. Suppose your strains are such as to change that slope to 10 feet—then it is just like sitting down.

Senator HOPKINS. And the water will rush in over the top?

Mr. BATES. And carry it right away.

Senator HOPKINS. Yes.

Mr. BATES. Now, then, it would scour not only the dam away, but, in my experience, I believe that at 85 feet head—and I had at Puyallup only 18—I believe that it would scour 150 feet deep.

Senator HOPKINS. The point I am getting at is this: That if the dam would go out, it would go from an overflow rather than an underflow of water?

Mr. BATES. Absolutely; yes, sir. I think there is not the least danger of an underflow.

Senator HOPKINS. Yes; that is the point I wanted to get at.

Mr. BATES. Especially if you keep your head low; and if you make your head high, and a dam of that character should go out, you can not put it back with mechanical means. It can only go back by trains, and that means years.

Senator HOPKINS. But there is no danger of your dam, or any dam that may be put there, being carried out by an underflow of water?

Mr. BATES. I do not think so.

Senator KITTREDGE. What is the height of your dam at Gatun?

Mr. BATES. The height of the crest is 75 feet. I have not overloaded it.

Senator KITTREDGE. Above what?

Mr. BATES. Above sea level. It is a matter of judgment.

Senator KITTREDGE. Sustaining what head of water?

Mr. BATES. A net head of 29 feet.

Senator KITTREDGE. How much more head of water, in your judgment, is it safe for any dam to be planned to sustain at that point?

Mr. BATES. I would not sustain over 40 feet.

Senator KITTREDGE. Why?

Mr. BATES. Because it takes so very much material to put it in, making it an expensive dam, because it would be so very expensive and long to repair if it ever broke away.

Senator KITTREDGE. You say, "if it ever broke away;" do you not expect to put a dam in there, if we adopt the lock plan, that will stay there forever, for all time?

Mr. BATES. It will, except in earthquake.

Senator KITTREDGE. Why do you think there is any danger in that regard, then?

Mr. BATES. I understand that to be an earthquake country, and it is quite possible that something of that sort may occur.

Senator KITTREDGE. Would not a general earthquake destroy any kind of a canal?

Mr. BATES. Yes; practically.

The CHAIRMAN. Any canal of any kind?

Mr. BATES. Any canal. All the canals are vulnerable in that respect—the sea-level canal just as much so as the lock canal. In fact, I consider the sea-level more so, because that Gamboa dam has such tremendous heads. Your danger from earthquake diminishes as your head of water increases.

Senator MORGAN. Mr. Bates, as to the dam of the minority report there. Is that lock on the east or the west side of that dam?

Mr. BATES. This is the east side, sir.

Senator MORGAN. The east side?

Mr. BATES. Yes, sir.

Senator MORGAN. Is your lock on the east or the west side?

Mr. BATES. On the same side.

Senator MORGAN. They are both on the same side?

Mr. BATES. Yes, sir.

Senator MORGAN. And on the same hill?

Mr. BATES. The same hill.

Senator MORGAN. The axis of your dam is the same as the axis of the dam proposed by the minority?

Mr. BATES. Yes, sir.

Senator MORGAN. Across the Chagres?

Mr. BATES. Yes, sir; only that the minority's dam is higher; consequently it is longer.

Senator MORGAN. Your dam is 75 feet high?

Mr. BATES. About; yes, sir.

Senator MORGAN. And the other one is how high?

Mr. BATES. One hundred and thirty-five feet.

Senator MORGAN. One hundred and thirty-five feet. Your dam is practically half as high as theirs?

Mr. BATES. A little more than half as high.

Senator MORGAN. And you raise the water how far—29 feet?

Mr. BATES. Twenty-nine feet.

Senator MORGAN. How high do they raise it?

Mr. BATES. Eighty-five feet.

Senator MORGAN. Then the choice between the two dams, taking them by themselves, in your opinion, depends upon the heights?

Mr. BATES. It depends upon the head—the head of water which they are sustaining.

Senator MORGAN. That means the height of the dam that backs the head of water?

Mr. BATES. The dam of the minority has 85 feet on one side and no feet on the other. The dam that I put at Gatun has 62 feet on one side and 35 on the other, making a net difference of 29 feet. Consequently my dam has to combat the pressure and the percolation due to a head of 29 feet instead of 85—about a third.

Senator MORGAN. Now, then, your estimate of the difference in volume between your dam and the dam proposed by the minority, as I understand it, depends upon the height of the dam? They have theirs too high, in your judgment?

Mr. BATES. In order to put in a flight of three locks they have made it high. I had to put in but one lock, and had no occasion to make it so high.

Senator MORGAN. Very good. Now, because you had no occasion to make it so high, and they had an occasion to make it so much higher, you think that your plan is a safer plan than the dam 85 feet high?

Mr. BATES. Surely.

Senator MORGAN. Yes; and that is your choice between the two dams principally?

Mr. BATES. Surely; yes, sir.

Senator MORGAN. You put a revetment of stone around your dam?

Mr. BATES. Yes.

Senator MORGAN. Or riprap, or cement, or whatever you please?

Mr. BATES. Stone. The minority make one around the foot, and they riprap the front of their dam. The essential principles of the construction of the dams are the same.

Senator MORGAN. Then I understand that there is no danger, in your opinion, of the water underwashing your dam?

Mr. BATES. I do not think so.

Senator MORGAN. And quite as little of its underwashing the dam of the minority report?

Mr. BATES. Quite as little, but more likely, inasmuch as you have 85 feet head as against 29.

Senator MORGAN. Very good; but take them together; they would be practically of equal solidity, would they not?

Mr. BATES. Yes, sir.

Senator MORGAN. And of course, therefore, practically equally capable of resisting the head of water?

Mr. BATES. As far as resistance goes; yes.

Senator MORGAN. One might not resist a head of water 85 feet high, and the other one might resist one that was lower—the height of your dam?

Mr. BATES. Using the same formula of construction.

Senator HOPKINS. One moment. From the answer to that question I do not know whether I understood him aright on my question. I understood you to say, Mr. Bates, on the construction of the minority dam or on the construction of your dam that there was no danger from an underflow.

Mr. BATES. Yes, sir.

Senator HOPKINS. That is correct, is it?

Mr. BATES. I think so.

Senator HOPKINS. That if either dam gives way, it would give way from an overflow?

Mr. BATES. From an overflow or fissure.

Senator HOPKINS. Yes; or a fissure caused by an earthquake?

Mr. BATES. Certainly.

Senator HOPKINS. Under no other conditions would there be any trouble with either type of dam?

Mr. BATES. I do not think there would.

Senator HOPKINS. Yes; that is what I wanted to know.

Senator MORGAN. So that there is practically no difference except one of the method of construction between the solidity, I will say, of your dam and the solidity of the dam of the minority?

Mr. BATES. Very little.

Senator MORGAN. But in case a fracture or a fissure should occur, your dam would be easier to replace than the other?

Mr. BATES. Very much.

Senator MORGAN. And would not have the same force in scouring the material away that had hitherto been put there?

Mr. BATES. No, sir; because the head is lower.

Senator MORGAN. Then that brings it to this proposition, if I understand it—that both dams would stand unless a fissure occurred?

Mr. BATES. Yes, sir.

Senator MORGAN. And then the question would be which would be the most disastrous in its effects and which would require the greatest expense to replace it?

Mr. BATES. Yes, sir.

Senator MORGAN. And that is the whole story?

Mr. BATES. That is the whole story.

Senator MORGAN. Do you consider your dam perfectly safe?

Mr. BATES. Yes, sir.

Senator MORGAN. And you consider the other one equally safe except for the danger of a fissure?

Mr. BATES. Except for the danger of a fissure or overflow, and the difficulty of putting it back if anything ever happens to it. It is going to be hard enough to put it there and much harder to ever put it back.

Senator MORGAN. Well, if it should ever happen I reckon we would have to put back the Island of Martinique and some other islands in the Caribbean Sea. [Laughter.] I believe I understand your propositions now, as far as I am concerned.

Senator DRYDEN. I want to ask Mr. Bates about the east and west breakwater that he speaks of on page 1624. I would just like to have you point those out and explain a little about them, Mr. Bates. You seem to think that that is rather a dangerous situation there.

Mr. BATES. If you will permit me, Senator, I will get the drawings of those.

Senator MORGAN. While you are getting ready to answer that question I want to ask one question. You mentioned the dam at Bohio, and said you thought it was entirely practicable to put a dam in there. In the dam that you would put in at Bohio, would you put in a rock foundation of any kind?

Mr. BATES. No, sir; I would use the same type of dam.

Senator MORGAN. Well, you have a rock foundation of your dam here, have you not?

Mr. BATES. Oh, you would put your dam between rock fills just the same.

Senator MORGAN. Would these rocks go down to solid rock, or would they rest upon the surface of the material?

Mr. BATES. They rest upon the surface, or within 20 feet of the surface. You first strip the dam site and then put your rock on it.

Senator MORGAN. Very good. Now, there is no such provision made in the dam of the minority?

Mr. BATES. Oh, I think so, sir; yes; I think so. They first strip the ground. They put rock at the toe of their slope 200 feet wide, and I understand they put riprap at the front of their dam. It does not appear to me that they put the volume of stone in the front of their dam which Mr. Morrison has advocated and which I have shown; but, on the other hand, there is no reason why they should not do it if they want to.

Senator MORGAN. Now about the rock that either of you would use—you, in the construction of the Bohio dam (which follows Mr. Morrison's idea), and in the construction of the dam of the minority report—in all of these cases the rock is put around there as a retaining wall within which to pack the earth?

Mr. BATES. Yes, sir.

Senator MORGAN. And not as a protection against the weight of the water that comes from above?

Mr. BATES. Oh, it acts in both capacities.

Senator MORGAN. It acts in both capacities? There is that much more weight added to the dam, and that is the reason I ask it.

Mr. BATES. Yes, sir.

Senator MORGAN. But in neither case is it because of the fact that the riprap is put in there or whatever kind of rock revetment you put around the dam—in neither case is it because it rests upon a rock foundation?

Mr. BATES. In neither case.

Senator MORGAN. That is all I wanted to ask.

Senator HOPKINS. I want to ask you one or two questions, Mr. Bates. In your testimony that has been printed you say (you did not state it orally here the other day): "The writer did not reckon upon buying steamships for nearly 50 per cent more than their value." What did you mean by that?

Senator DRYDEN. Mr. Bates covered that earlier.

Senator TALIAFERRO. I do not think he covered it fully.

Senator HOPKINS. If he did, I did not hear it.

Senator DRYDEN. All right.

Senator HOPKINS. What do you mean by that?

Mr. BATES. I have already explained—

Senator HOPKINS. Well, just leave that out, and explain it to me. I did not hear any of it.

Mr. BATES. The cost of those ships was \$610,000 each.

Senator HOPKINS. Of what ships?

Mr. BATES. The *Mexico* and *Havana*.

Senator HOPKINS. It was what?

Mr. BATES. It was \$610,000.

Senator HOPKINS. How do you know that?

Mr. BATES. I was informed by a gentleman who is in the business.

Senator HOPKINS. By whom?

Mr. BATES. I have already named him—Mr. Langell.

Senator HOPKINS. How did he know the value of them; or what they cost?

Mr. BATES. He was familiar with making up the estimates on which bids were made; and, as I have said, he informed me that one company bid \$550,000 for those ships, and the Cramps \$610,000; and because of the relations of the Ward Line to the Cramps, the Cramps took the contract at \$610,000. These vessels were five or six years old—

Senator HOPKINS. Before you get through with this, right at that point, let me ask you this: Who is this man you speak of?

Mr. BATES. At present he is the man connected with the New York Shipbuilding Company whose business it is to make up the estimates upon which bids are made.

Senator HOPKINS. Is he living in New York now?

Mr. BATES. No; he lives at Camden, where these works are.

Senator HOPKINS. That is all you know about the matter of paying 50 per cent more, is it?

Mr. BATES. The way I got at it was this: The P. & O. Steamship Company, the great English steamship company with which I am familiar, and other companies write off 7 per cent per annum from the value of a ship. Applying that principle to the *Havana* and the *Mexico*, I consider that those vessels were really worth, from depreciation, about from \$425,000 to \$450,000 apiece.

Senator HOPKINS. Do you know anything about the condition of the ships from the time that they were first launched up to the time that they were purchased, personally?

Mr. BATES. I do not, personally; no.

Senator HOPKINS. Do you know anything about the condition in which they were kept from year to year?

Mr. BATES. I assume that they were kept as well as vessels can be kept.

Senator HOPKINS. Do you know? I do not want any assumptions. I want to know if you know anything about it?

Mr. BATES. No, sir.

Senator HOPKINS. Do you know what condition the ships were in at the time they were purchased?

Mr. BATES. I know nothing about the condition of the ships.

Senator HOPKINS. Have you ever seen them?

Mr. BATES. No.

Senator HOPKINS. Then the judgment which you have expressed here in this pamphlet before me was founded upon the statement made by this gentleman in New Jersey?

Mr. BATES. Yes, sir.

Senator HOPKINS. And the fact that they charge off 7 per cent per annum for the use of a vessel?

Mr. BATES. Not only that, but from the knowledge of the sizes of these vessels, and from the fact that I have built and owned vessels myself, and I am accustomed to figuring on that class of work.

Senator HOPKINS. Do you know whether these vessels had depreciated any in their value at the time that they were purchased from what they were at the time they were first launched?

Mr. BATES. Every vessel does, sir.

Senator HOPKINS. But do you know anything about these vessels?

Mr. BATES. I simply apply to them the broad principle that every vessel depreciates from the day it leaves the stocks.

Senator HOPKINS. Is it not a fact that vessels can be kept in good condition by repairs so that a vessel twenty years from now can pass "A 1"—a vessel 20 years old?

Mr. BATES. The *Aurania*—

Senator HOPKINS. No; answer my question. Is not that a fact?

Mr. BATES. No, sir; it is not a fact.

Senator HOPKINS. Is it not a fact that vessels are kept in such repair that they pass with insurance companies A 1 when they are twenty years of age?

Mr. BATES. It is one thing to pass with insurance companies and another thing to have a selling value.

Senator HOPKINS. On the question of a selling value, do you say that a vessel that is 20 years of age has never been passed as A 1?

Mr. BATES. I say that a vessel that is 20 years of age is not worth what she was when she was built, and nobody can make her so, unless there come extraordinary circumstances.

Senator HOPKINS. What do you mean by "extraordinary circumstances?"

Mr. BATES. A war.

Senator HOPKINS. Well——

Mr. BATES. You give your "kingdom for a horse."

Senator HOPKINS. You mean unless there is a greater demand than there ordinarily is for a vessel?

Mr. BATES. Yes, sir.

Senator HOPKINS. What do you know about the steam dredges that were used there that you say have depreciated, say, 50 per cent?

Mr. BATES. You must not misunderstand it in that fashion, Senator.

Senator HOPKINS. The 50 per cent does not apply to steam dredges?

Mr. BATES. Only to the ships, sir.

Senator HOPKINS. What do you know about their paying more for steam dredges than they were worth?

Mr. BATES. My objection in that clause—what I mean to say is that I would not buy dredges until I knew what I was going to do.

Senator HOPKINS. Do you know whether any exorbitant price was paid for any dredges?

Mr. BATES. No; I do not think there was.

Senator HOPKINS. Was any exorbitant price paid for any shovels that were purchased?

Mr. BATES. I do not think there was.

Senator HOPKINS. Or for any locomotives that were purchased?

Mr. BATES. I do not consider that point at all. What I have to say relates to the fact——

Senator HOPKINS. Now, wait a minute; I will get at that. But, so far as dredges, shovels, and locomotives were concerned, you have no information that would warrant your saying that the Government paid any more than those dredges, shovels, and locomotives were worth?

Mr. BATES. I have not said so.

Senator HOPKINS. Do you say so now?

Mr. BATES. I never have said that they paid any more for them than they are worth.

Senator HOPKINS. Then, your criticism is that they have purchased some before they needed them?

Mr. BATES. Before they knew what they were going to do.

Senator HOPKINS. That does not answer my question.

Mr. BATES. Before they needed them.

Senator HOPKINS. Now, take locomotives. What locomotive, or locomotives, have they purchased there that they did not need?

Mr. BATES. The first point, Senator, is this——

Senator HOPKINS. No, no; take the locomotives first.

Mr. BATES. With the locomotives, the number ordered depended upon what they meant to do at Culebra. Now, then——

Senator HOPKINS. How many of them did they order?

Mr. BATES. You have it in the record—120.

Senator HOPKINS. One hundred and twenty?

Mr. BATES. One hundred and twenty have been ordered, as I recall for the Commission, and 24 for the Panama Railroad.

Senator HOPKINS. Yes. Do you say that at the time that that order was given they did not need that many?

Mr. BATES. I say that they never studied the Culebra proposition to know whether they should use locomotives, steam traction, or electric traction, and that there was never any study by anybody competent to make it of the Culebra excavation; and it is altogether a question with me whether that is the best way to do it.

Senator HOPKINS. By locomotive, you mean? Have you ever heard any other engineer claim that they could use other than steam locomotives?

Mr. BATES. It is perfectly feasible to use electric traction.

Senator HOPKINS. Have you ever heard any other engineer, American or foreign, say that they could use other than a steam engine?

Mr. BATES. I discussed this matter, for instance, with Mr. Coffin, the president of the General Locomotive Company, and pointed out to him—

Senator HOPKINS. We have your view; but I ask you if you know of any other American engineer, or any foreign engineer, that has claimed that they could use other than steam engines there in the construction of the canal—I mean, economically?

Mr. BATES. Yes; for years people have had in mind the application of electricity to the Panama and the Nicaragua canals.

Senator HOPKINS. And who has advocated the use of electricity over steam for the construction of this canal, in the operation and use of locomotives?

Mr. BATES. I do not recall at the moment anyone who has; but, on the other hand, there are people who have. I will look it up for you and give you the data.

Senator HOPKINS. Do you know how many dredges were ordered?

Mr. BATES. Yes. There have been two dipper dredges ordered—one for Colon and the other for La Boca—at a price of about \$100,000 each.

Senator HOPKINS. Are those dredges now in use?

Mr. BATES. No, sir; they are not yet delivered.

Senator MORGAN. Not yet delivered?

Mr. BATES. No, sir. Parties have gone down there to assemble them.

Senator HOPKINS. How many shovels? Do you know anything about those that have been ordered?

Mr. BATES. Some 62 shovels, I think.

Senator HOPKINS. Do you know whether those that have been ordered are in use at all?

Mr. BATES. I think the total order is about 100. There are 17 in use. An engineer who came to my office just two days ago told me there were 17 in use when he left the Isthmus, about ten days ago.

Senator HOPKINS. How many have been delivered; any more than 17?

Mr. BATES. I do not know.

Senator HOPKINS. Now, to get back to these two ships, do you know anything about the conditions under which they were purchased?

Mr. BATES. No; no.

Senator HOPKINS. You do not know anything at all about the circumstances under which they were purchased?

Mr. BATES. No, sir.

Senator HOPKINS. Do you know anything about the demand in transportation for vessels of the type of these two ships?

Mr. BATES. I can easily imagine that there was a very large demand, because there was a tremendous amount of stuff bought for the Isthmus—free material.

Senator HOPKINS. I am not speaking of the demand for the Isthmus.

Mr. BATES (continuing). Which made the demand.

Senator HOPKINS. I ask you the question, do you know anything about the demand for vessels of this type in the transportation business at the time these ships were bought?

Mr. BATES. I know that there was a fair demand for vessels of that character, and that these two vessels were on the Mexican line.

Senator HOPKINS. Do you know whether any vessels of this type, and of the quality, character, and condition of these vessels, could have been bought anywhere in the world cheaper than these were bought at the time that they were purchased?

Mr. BATES. They could have been built, brand new—

Senator HOPKINS. No; wait a moment. Answer my question, please.

Mr. BATES. I do not know of any vessels that could have been bought for that price or any other price.

Senator HOPKINS. You do not know of any that were for sale then?

Mr. BATES. I am not cognizant of that.

Senator HOPKINS. Do you know how many vessels of that type were actually in existence in the commercial world?

Mr. BATES. I suppose there were just two; these being sister ships, there were just two vessels like that.

Senator HOPKINS. Of that type, and that—

Mr. BATES. If you mean by size; but of that type—of course, you know, all vessels differ; so that if you mean those identical dimensions, if you make a specification that fits only those vessels, those were the only vessels that could be had.

Senator HOPKINS. Take vessels that could be utilized for the purposes to which these were put—how many were in existence in the commercial world?

Mr. BATES. I will look that up.

Senator HOPKINS. You do not know, do you?

Mr. BATES. No.

Senator HOPKINS. Then, you have no knowledge of your own from which you could say whether the Government paid too much for those vessels or not?

Mr. BATES. I judged that it paid too much, because a new vessel could be built for the price that it paid.

Senator HOPKINS. How long would it take to construct a new vessel of that type?

Mr. BATES. About eight or nine months—say ten months.

Senator HOPKINS. Where could such a vessel as that be built within ten months—at what shipyard?

Mr. BATES. The New York Shipbuilding Company.

Senator HOPKINS. The New York Shipbuilding Company?

Mr. BATES. Yes, sir.

Senator HOPKINS. Within ten months from the time the order was given?

Mr. BATES. Yes, sir, very probably; I think so. I am very certain it could have been built in that time at the Armstrongs', for instance.

Senator HOPKINS. That is all.

Senator TALIAFERRO. I suppose, Mr. Bates, that you mean by that statement that in the purchase of a large quantity of tools down there on the Isthmus, before the type of canal was decided upon, the Commission has acted indiscreetly.

Mr. BATES. I think so.

Senator TALIAFERRO. That was the point?

Mr. BATES. That was the point I wished to bring out—the type should be decided first.

Senator TALIAFERRO. And as a matter of fact, where they paid \$1,300,000 for two ships 10 years old, duplicates of those ships could have been built and delivered new for that amount of money?

Mr. BATES. Yes, sir.

Senator TALIAFERRO. That is the point?

Mr. BATES. That is the practical point; yes, sir.

Senator MORGAN. Mr. Bates, if you are through with that matter, I will ask you a question. A sea-level canal constructed in from the bay of Limon would remain at sea level, if I understand the situation out there, practically until it reached Bohio, without any very deep embankments—perhaps without any?

Mr. BATES. Yes, sir; the elevation at Gatun of the surface of the swamp is about 4 or 5 feet above sea level.

Senator MORGAN. Yes.

Mr. BATES. And that level runs practically to Bohio, and the lowest recorded water of the Chagres at Bohio is just mean sea level.

Senator MORGAN. That would leave the banks of the canal how high above the surface of it at Bohio?

Mr. BATES. The natural bank just below Bohio would perhaps be 6 or 8 feet.

Senator MORGAN. Six or eight?

Mr. BATES. Yes.

Senator MORGAN. Now, continue that sea level on up to Gamboa; how high would the banks of the canal be above the sea level and above the surface of the canal at, say, Gamboa, taking the river there as the central point?

Mr. BATES. At Gamboa the elevation of the river is 45 feet above sea level. The bank is higher than that—about 5 feet. But these measurements that I give are the heights of the natural conformation and not the height of the spoil banks adjacent.

Senator MORGAN. I understand that. I am taking the natural surface as the indication of the height. It is about 50 feet, then, that the natural surface at Gamboa would be above the surface of the canal?

Mr. BATES. Yes.

Senator MORGAN. About 50 feet?

Mr. BATES. Yes.

Senator MORGAN. Is there good ground at Gamboa for putting in locks?

Mr. BATES. At Gamboa?

Senator MORGAN. Yes.

Mr. BATES. The French have a site at Obispo which was rock. That is across the Chagres from Gamboa, on the right bank of the Chagres going up—on the west bank of the Chagres.

Senator MORGAN. Yes.

Mr. BATES. That was a rock lock site adopted by the old company when they were obliged to abandon the sea-level scheme.

Senator MORGAN. That location for the locks is in a ridge that makes out toward Gigante; it is in a ridge there, is it not?

Mr. BATES. Oh, Gigante, sir, is right above Bohio.

Senator MORGAN. I know it is; I mean the direction of Gigante. It is a ridge that comes in there at Bohio, and the locks are to be located on the left bank of the Chagres River? I do not mean on the bank, but on the left side?

Mr. BATES. That is, the Bohio locks were to be on the left bank of the Chagres; yes.

Senator MORGAN. The left bank of the Chagres River?

Mr. BATES. Yes, sir.

Senator MORGAN. Very good. Then there is a ridge running out toward Gigante?

Mr. BATES. Yes, sir.

Senator MORGAN. From there?

Mr. BATES. Yes, sir.

Senator MORGAN. Now we will go up to Gamboa. Is there suitable and proper ground at Gamboa for putting in locks?

Mr. BATES. You could put in a lock at Obispo, but nobody, in the present project, is suggesting a lock at Gamboa.

Senator MORGAN. Well, suppose I suggest one?

Mr. BATES. Then you would have to put it at Obispo, where the old French location was.

Senator MORGAN. At Obispo, out beyond Gamboa, farther to the south than Gamboa?

Mr. BATES. There is Gamboa [indicating].

Senator MORGAN. Yes.

Mr. BATES. There is Gamboa here. Now, the Obispo lock was located in here somewhere.

Senator MORGAN. At Gamboa is there any ground suitable for putting in locks?

Mr. BATES. I do not think so; because you could put a lock going with the Chagres, but that would not take you to Panama. On the other side you have not very good ground for a lock unless you cut into the side of this hill or into the side of that hill [indicating]. You can put it right above Gamboa there, right at the beginning of the Culebra section.

Senator MORGAN. Yes; that is good ground for locks, is it?

Mr. BATES. Oh, yes.

Senator MORGAN. What would be the depth of the water at that place, at Obispo, below the surface of the earth—the level of the water?

Mr. BATES. The level of a sea-level canal?

Senator MORGAN. Yes.

Mr. BATES. It would be 45 feet at Gamboa.

Senator MORGAN. How at Obispo?

Mr. BATES. Practically the same.

Senator MORGAN. Practically the same?

Mr. BATES. Yes, sir.

Senator MORGAN. So if you were running a sea-level canal to Obispo

you would have, when you got there, a natural bank on either side of about 40 feet elevation above the surface of the canal?

Mr. BATES. From 45 to 50 feet.

Senator MORGAN. And that would be a suitable and safe location for putting in locks?

Mr. BATES. It would be a safe location; it would not be a suitable one.

Senator MORGAN. Why not suitable?

Mr. BATES. Because then you would have to feed your summit level entirely from storage in a lake above Gamboa or Alhajuela, and there is not water enough then for a lock canal at all.

Senator MORGAN. Not water enough in the Chagres River?

Mr. BATES. Above Gamboa—no, sir.

Senator MORGAN. Above Gamboa?

Mr. BATES. No, sir.

Senator MORGAN. No matter what dam you put in there you could not get water enough to feed that canal?

Mr. BATES. You could not.

Senator MORGAN. The sea-level canal that would run from the bay of Limon to Obispo would have its water furnished from the sea?

Mr. BATES. Yes.

Senator MORGAN. Would it require any great amount of water in addition to that in order to keep the canal in operation between Obispo with a sea-level canal in operation between Obispo and the bay of Limon?

Mr. BATES. Why, you have the ocean; the ocean is your inexhaustible reservoir for a sea-level canal.

Senator MORGAN. That is what I supposed.

Mr. BATES. Yes, sir.

Senator MORGAN. So that you would have to borrow no water from the Chagres at all in order to run that end of it out. How many miles would that be from Obispo to the bay of Limon?

Mr. BATES. It is 45 kilometers—that is, 31 miles—30½ miles.

Senator MORGAN. Thirty and one-half miles of sea-level canal, reaching from the Bay of Limon to Obispo, would be filled with sea water?

Mr. BATES. Yes.

Senator MORGAN. Would there not be enough water left in the Chagres River, with a dam across at Gamboa, to supply a lock level out to the other end?

Mr. BATES. No, sir; because you would only have the water that falls in the Chagres watershed above Gamboa; and that is only about half of the total water supply of the Isthmus, and I think that it takes all the water supply of the Isthmus to supply a lock canal, no matter of what description, and the amount of water that you use is determined by your upper lock. If, for instance, you have a summit level at 60 feet, the water that supplies your summit level also will supply your lower level; so that if you put a lock at Obispo you would have only the water supply above Gamboa. If you put your lock at Gatun you would have double the amount of lockage supply.

Senator MORGAN. What is the height of the dam the minority propose at Gamboa?

Mr. BATES. The minority do not propose any dam at Gamboa.

Senator MORGAN. Oh, yes. What is the height of the dam that has been heretofore proposed at Gamboa to back the Chagres River up, say, to Alhajuela? What would be the height of the dam requisite?

Mr. BATES. The sea-level scheme proposes a dam whose crest is 180 feet above sea level, and in which the head of water may mount to 170 feet.

Senator MORGAN. That is for controlling works?

Mr. BATES. Yes, sir.

Senator MORGAN. And water power?

Mr. BATES. Yes; if anybody could use it.

Senator MORGAN. What is the area of that lake above the dam proposed by the sea-level report, in square miles?

Mr. BATES. I think it is stated to be about 37 square miles; but I would have to look that data up.

Senator MORGAN. You would have to look it up?

Mr. BATES. Yes, sir; I think it is 37 square miles.

Senator MORGAN. And you think that a lake of that size would not be sufficient to supply a lock canal between Obispo and, say, Miraflores?

Mr. BATES. That lake must be fed by the run-off of the watershed, so that if that run-off is, for instance, 4,000 cubic feet per second, then the 4,000 cubic feet per second is all you have to use, no matter whether your lake is as big as Lake Superior.

Senator MORGAN. What is the approximate distance between Obispo and Miraflores?

Mr. BATES. Ten miles. Obispo is 31 miles and Miraflores 41—just 10 miles.

Senator MORGAN. Ten miles. Now, do you think that the supply of water from the Chagres River would not fill the prism of the canal between Obispo and Miraflores?

Mr. BATES. I think that it would fill it, but it would not be enough to lock 50,000,000 tons per annum through that section.

Senator MORGAN. You think you would require more water than the Chagres River would afford for that purpose?

Mr. BATES. Than that portion of the Chagres would afford.

Senator MORGAN. Yes; I am talking about the reservoir as far down as Gamboa.

Mr. BATES. No, sir.

Senator MORGAN. There are still other affluents that come in there—the Obispo and several other affluents that come in between Miraflores and Gamboa?

Mr. BATES. They are very small; comparatively small.

Senator MORGAN. Yes; comparatively small. Now, taking them all together, it is your opinion that that 10 miles of lock canal could not be sufficiently supplied with water for commercial purposes, for floating ships in the canal?

Mr. BATES. Yes, sir.

Senator MORGAN. With a dam 185 feet high, I believe it is, at Gamboa?

Mr. BATES. Yes, sir.

Senator MORGAN. That is what I wanted to ascertain.

Senator TALIAFERRO. Mr. Bates, what would you consider to be the ideal type of canal across that Isthmus, disregarding the question of cost and the question of the time necessary to construct it? What do

you regard, as an engineer, the ideal type of canal across that Isthmus? Is it a lock or is it a sea-level canal?

Mr. BATES. It is a lock canal; a lock canal with the locks not in flight, but single, separated from each other not less than 3 or 4 miles; with the summit lake beginning at Gatun, extending through to Pedro Miguel, at an elevation of not to exceed 62 feet above sea level; with a controlling dam at Gamboa and another at Alhajuela, so as to divide your risks, not having it all at Gamboa, as the majority propose; with your lower locks at Mindi and at Sosa Hill. With such a plan you will have the greatest amount of lake navigation, the most absolutely assured control of the Chagres; it is the easiest to construct, the most sanitary, and has all the advantages that I can think of for anything that can be done.

Senator HOPKINS. Do you, under any conditions, favor a sea-level canal, Mr. Bates?

Mr. BATES. No, sir.

Senator HOPKINS. Now, can you briefly state why you do not favor a sea-level canal?

Mr. BATES. I am discussing the report—

Senator TALIAFERRO. Now, Mr. Bates, if you will pardon me—

Mr. BATES. I have the heads here that I want to refer to.

Senator TALIAFERRO (continuing). Instead of criticising the plan that has been submitted here, if you would only answer from your own point of view as an engineer, it would be so much more satisfactory, I think, to the committee.

Mr. BATES. Yes, sir.

Senator HOPKINS. My question was propounded upon this idea: Some engineers claim that a sea-level canal is the true type of canal to construct there. Others say it is not. In answer to my question you say that under no conditions would you put a sea-level canal across the Isthmus.

Mr. BATES. Yes, sir.

Senator HOPKINS. Now, just in a few brief words, please make that plain to a layman.

Mr. BATES. One of the first things is the terminal harbors at each end. For the benefit of this country, I consider that the best harbors that can be made are combined salt-water and fresh-water harbors adjacent to each side.

Senator TALIAFERRO. Now, that suggestion does not go to the question of the canal, Mr. Bates, at all. I should consider that the harbors could be made just as useful with one type of canal there as with another; and what we wanted to ascertain was your objection to the sea level as a type of canal, not the question of intermixing sea water there with fresh water, as you would do with a lock canal.

Mr. BATES. Exclusive of the harbors, then, and the type of the sea-level canal, which would have only salt-water harbors, the first objection that I would recite with reference to the vessel is that she travels all the way in a constricted channel. That being so, her average speed will be less, and it will take longer to cross the Isthmus in a sea-level canal from the dispatching station on one side to the dispatching station on the other. I speak of large-sized ships.

Senator TALIAFERRO. Just for information, at what speed do you estimate it would be safe for a large-sized ship to traverse a sea-level canal, as recommended by a majority of the consulting board?

Mr. BATES. From 4 to 5 miles an hour.

Senator TALIAFERRO. And the length of the canal is what?

Mr. BATES. The distance is forty-five miles.

Senator MORGAN. In a sea-level canal?

Mr. BATES. Forty-five miles from the dispatching stations—44 miles from the dispatching station off Colon to the tide lock at Sosa Hill.

Senator MORGAN. You have to add 3 miles to that to go down to the islands, do you not?

Mr. BATES. Yes, sir; but your dispatching station really is your standard for isthmian transit.

Senator HOPKINS. Your first objection, as I understand it, is the restricted speed of the vessels in crossing the Isthmus. What other objection have you to the sea-level canal?

Mr. BATES. In making a regulation of the Chagres, you have in the sea-level proposition a dam at Gamboa 180 feet high, with a head up to 170 feet, and I regard that as a very high dam and a very high head. The amount of excavation in the Culebra cut runs it up to enormous cost. You have the most lower Chagres diversion work. In order to keep the water of the watershed out of the canal, the plan practically provides for diversions on both sides. On the east side it follows closely the valley of the Chagres, and finally debouches into the Bay of Manzanillo. On the west side, instead of making diversions adjacent to the canal, they have been cut out.

Senator HOPKINS. Who has cut them out?

Mr. BATES. The sea-level proposition—the majority.

Senator HOPKINS. We do not care whose type it is. It is a sea-level canal. I do not care whether it is the majority's or whose it is.

Mr. BATES. Yes.

Senator HOPKINS. I simply wanted to get your objections to any kind of a sea-level canal.

Mr. BATES. It has the most lower Chagres diversion work—an enormous quantity of it. It has the highest cost of excavation, because you have to do more rock work under water. It takes the most plant to do it. There is the least utilization of the old French excavation, because their spoil banks are so close to their line that half of them have to be dug out and carted away, so you lose half the advantage of the old French excavation, and the other plans lose a portion also. You have more pumping during construction on that plan than any other, and pumping is difficult. You have the greatest difficulties in the distribution of spoil. In this whole report of the advisory board I have not been able to find a single line that says where they are going to take the spoil from any part of the canal, practically.

Senator TALIAFERRO. The things you are stating now, Mr. Bates, go to the question of cost?

Mr. BATES. Yes.

Senator TALIAFERRO. And I intended to eliminate, in my question, all considerations of cost. Let me go back and see if I did.

(By request, the stenographer read the question of Senator Taliaferro, as follows:)

“Mr. Bates, what would you consider to be the ideal type of a canal across that Isthmus, disregarding the question of cost and the question of the time necessary to construct it? What do you regard, as an

engineer, the ideal type of canal across that Isthmus? Is it a lock or is it a sea-level canal?"

Senator TALIAFERRO. Now, that disregards the question of cost and disregards the time required to construct it.

Mr. BATES. Then it would be entirely from the standpoint of a ship?

Senator HOPKINS. Well, would it?

Mr. BATES. That is what I am asking you.

Senator TALIAFERRO. We want to get your ideas; at least I do. One of your objections to the sea level was that it retarded the speed of the vessels in crossing the isthmus?

Mr. BATES. Yes, sir.

Senator TALIAFERRO. Now, is there any other objection to a sea-level canal, disregarding the time and the expense of the construction of the canal?

Mr. BATES. Increasing the time of transit increases the risk to the ship.

I have my other points right here.

It has the greatest curvature affecting navigation. When there is a curve on a lake waterway, the curve does not affect navigation. When it is in a constricted channel, it does. There are the greater dangers of taking these curves. If you could have a sea-level canal without any reference to the Chagres regulation, without any reference to time or cost, then naturally it is an ideal type of canal; but you can not do it.

Senator TALIAFERRO. That is the kind of canal we ought to have, then; is it?

Mr. BATES. But you can not get it.

Senator TALIAFERRO. That is a question as between the engineers. If I go to you to solve an engineering problem, and you say to me, "I can solve that problem at this expense," I would be justified, it seems to me, in relying on your judgment and advice. There were assembled here in this city a number of distinguished engineers. They tell us without any qualification or question that the waters of the Chagres and of all of the small streams which traverse that section and which ordinarily would empty into that canal can be successfully controlled. Now, do you mean, Mr. Bates, to tell the committee that all of those engineers are absolutely wrong on that question of controlling the Chagres?

Mr. BATES. I have not said that they could not control it. What I do say is that in controlling it they use identically the principles which I advanced in my project and no other. You will find that there for the first time appears the under-sluice dam and the divided river.

Senator TALIAFERRO. I noticed that in your statement, Mr. Bates.

Mr. BATES. Yes, sir.

Senator TALIAFERRO. And I want to say that, however that may be, if it is so that this board has adopted your ideas in that respect, so much the greater hesitation, I take it, you would have in saying that the recommendation of the board was at fault?

Mr. BATES. The recommendation—

Senator TALIAFERRO. If they bring your ideas to us, we are ready to adopt them if they are good ideas.

Mr. BATES. I object to the sea-level canal on account of cost and time and life and sanitary conditions in constructing it, and when you

have got it you have not got a canal as good as the lock canal. It takes you 50 per cent longer time, with a big ship, to go through it, and I can not see any advantage whatever in the sea-level canal. You have to have one lock anyway.

Senator HOPKINS. Well, let me ask you this question: Is it not a fact that it would cost more to keep a sea-level canal clear, so that vessels could navigate it, than a lock canal?

Mr. BATES. Yes, sir; for dispatch, because you have got to have more stations—

Senator HOPKINS. But the point I am getting at is, would not the Chagres and the other rivers there on the Isthmus carry refuse matter into the canal that would lodge there and would have to be dredged out, and all that sort of thing, so as to make it more expensive and more dangerous to navigation than a lock canal?

Mr. BATES. By making the diversion, sir, on the sides big enough, it is my belief that you can keep the silt deposits out of the canal. I do not believe in resting the integrity of the whole sea level or any other enterprise on one great thing like the Gamboa dam. I would divide the risk.

Senator TALIAFERRO. You spoke of the health of the Isthmus.

Mr. BATES. Yes, sir.

Senator TALIAFERRO. I suppose you have studied health questions, sanitation, etc.

Mr. BATES. In my volume (the large one) I made as exhaustive study as possible of the records of the navy and army in the Tropics to show the relative health of a man afloat and a man ashore in the Tropics. It came out that the man afloat had from six to sixty times the immunity that a man ashore had. Consequently, the records appeared to absolutely demonstrate that the more lake area you had the freer you would be from military hazards, because you could operate a smaller force of highly skilled men and take extremely good care of them on a floating plant.

So that in the lock canal which I have advocated there is the most lake length that it is possible to get from Mindi to Obispo and from Miraflores to Sosa, leaving but about 8 or 10 miles which may be said to be land-locked or typical canal navigation. And in starting, I would first put in my dam at Gamboa across the Chagres, and then I would be afloat all the way to Bohio. I do the same thing at the same time on the other side, and then, next, I would have my dam at Gatun; and then I would have water all the way to the foot of the Culebra. You can have all but 8 or 10 miles absolutely finished in three years.

Senator HOPKINS. On a lock system?

Mr. BATES. Yes, sir.

Senator MORGAN. Your proposition has how many locks in it—three or four?

Mr. BATES. The preferred plan has four.

Senator MORGAN. Your plan?

Mr. BATES. The preferred plan, B, has four.

Senator MORGAN. Where?

Mr. BATES. One of them at Mindi, one at Gatun, one at Pedro Miguel, and the other at Sosa.

Senator MORGAN. That is all?

Mr. BATES. Yes, sir.

Senator DRYDEN. Now, about those breakwaters: You seem to think that there is a good deal of danger, or would be, in those harbors there in the event of storms.

Mr. BATES. Yes, sir.

Senator DRYDEN. Which both of the other plans call for?

Mr. BATES. Yes, sir; the east breakwater runs out from Colon Light to a point on the 40-foot contour. Right at that point is a reef carrying 22½ feet of water right under the lee of a ship entering, and that constitutes something which should be avoided if it can be. That breakwater is exposed to the trade winds, and, the water being deep, the blocks of which it is made, if you want to have a solid structure, would have to be 15 or 20 ton blocks. Otherwise they would be moved by the force of the sea.

On the west side we have a breakwater which is 4½ miles long. Now, the line of direction of a heavy sea in "northers" is slightly oblique to that, not at right angles, and not, as I take it, directly into the eye of the wind. I think that the line is more nearly this. [Indicating.] So that I have considered that it is unwise to make a breakwater across the bay, the water being so deep, but to make one in comparatively shallow water, 18 to 21 or 22 feet deep, starting from the vicinity of Mindi Point, making the channel from Mindi Point to this contour a submerged channel, just as your channel is at New York, or in leading up to Port Said, and in very many places in the world.

Senator HOPKINS. Right there, let me say that I may be mistaken, but my impression is that you could not have a channel of that character, the same as we have at New York, at that point. I would like to have you elucidate that a little.

Mr. BATES. In making a submerged channel, the maintenance of it consists simply of loading a hopper dredge, such as I am using at Galveston, and taking the material and either depositing it at sea or putting it in here [indicating].

Senator HOPKINS. Yes; I understand how you would put it out; but are not the trade winds and other conditions such that it would fill right up, and you could not keep it open?

Mr. BATES. I do not think so.

Senator HOPKINS. Well, have you made an investigation, Mr. Bates? Now, I do not know where I got the impression, but I have had the impression that it would be impossible to have that there; and if you have some personal or specific information on that subject, I would like to have you give it to us, as to the condition of the soil there, and the influence that the trade winds would have upon any such project as you have suggested.

Mr. BATES. In that portion of the bay which is outside of the 21 or 22 foot contour line you are below the line of wave motion. I have put my breakwater, then, to cover that portion of the bay where those difficulties would obtain, that being perfectly covered. This that is colored with blue here can be taken out, not with the hopper dredges, but simply put upon that reclaimed land, and as they would be quite free of wave motion that is easy to maintain. So that instead of putting out very expensive breakwaters here, or in this direction, the water, so to say, protects itself. I would expect to have, as all canals must have, powerful dredges of maintenance in order that any deposits might always be removed.

Senator HOPKINS. To keep it dredged out?

Mr. BATES. Yes, sir.

Senator MORGAN. Will you kindly point out there, Mr. Bates, where those two easternmost lakes are located?

Mr. BATES. On this plan—this is the plan A, with only two locks—one at Mindi and the other at Sosa Hill, on the other side a flat summit level. Then the lock is right here on the side of Jaramillo Hill. That is reached by a basin occupying the present bed of the old canal, but very much widened. Then from the lock over to the hill is a low dike or dam about 3,000 feet in aggregate length between those small hills, and that holds up a head of water in here of about 30, 32, or 33 feet, whatever you decide. On the four-lock canal I put in the Gatun dam from Gatun Hill to the westerly hill, which shows in more detail on one of these plans which you have already seen.

Now, on the Pacific side—

Senator MORGAN. No; I want to get that. What height of water do you get there at the Gatun dam above the sea level?

Mr. BATES. On the project B, the preferred one, the height here is 62 feet.

Senator MORGAN. Sixty-two?

Mr. BATES. Sixty or 62. On the other side of the dam it is, say, 33, making a difference of 29 feet. That means one lock at Mindi in this hill, another lock at Gatun in the Gatun Hill.

Senator MORGAN. What is the height of the lock at Mindi?

Mr. BATES. Thirty-three feet.

Senator MORGAN. Thirty-three?

Mr. BATES. Yes, sir.

Senator MORGAN. And then you add to that how much?

Mr. BATES. Twenty-nine, making 62.

Senator MORGAN. Sixty-two?

Mr. BATES. Yes, sir.

Senator MORGAN. And then, with that elevation there, you get 62 feet for the surface of your canal above the bottom of the prism—

Mr. BATES. You carry that clear to Pedro Miguel.

Senator MORGAN. Yes; to Pedro Miguel.

Mr. BATES. That is the point right here [indicating].

Senator MORGAN. Yes.

Mr. BATES. This would be the Culebra cut and here is Pedro Miguel [indicating].

Senator MORGAN. Now, you would fill all of that distance between Gatun and Pedro Miguel with the waters of the Chagres River and its affluents?

Mr. BATES. Yes, sir.

Senator MORGAN. You would find it quite sufficient, would you?

Mr. BATES. Yes, sir.

Senator MORGAN. No danger of running it down in case of a heavy patronage of the canal?

Mr. BATES. I think not. I think you would have capacity for 100,000,000 tons.

Senator MORGAN. The only water supply you would have would be the rainfall—

Mr. BATES. The run-off, the watershed of the whole distance.

Senator MORGAN. You would have the watershed of the Chagres and its affluents between Gatun and Pedro Miguel?

Mr. BATES. Yes, sir.

Senator MORGAN. You would take them all in?

Mr. BATES. Yes, sir.

Senator MORGAN. With no controlling works anywhere except at the two dams?

Mr. BATES. At Gamboa and at Alajuela; and I also propose a dam on the Cano, which is quite a little stream.

Senator MORGAN. You propose to put in a dam at Gamboa?

Mr. BATES. At Gamboa.

Senator MORGAN. And at Alajuela?

Mr. BATES. And at Alajuela. Each of them has exactly the same height as the Assouan dam. I would also have a dam on the Cano, which has quite a watershed.

Senator MORGAN. You want those dams to prevent the flood waters from coming into this great basin you have here?

Mr. BATES. Yes, sir; I want to let the water into the basin gradually in case of a flood.

Senator MORGAN. Why do you want a dam at Gamboa and also at Alajuela?

Mr. BATES. Because I want to divide the risks.

Senator MORGAN. You want to divide the risk?

Mr. BATES. Yes, sir; either dam would be big enough to work alone; just exactly as in feeding a steam boiler on a vessel you have two feed pumps, so if one breaks down you have another one.

Senator MORGAN. You want to make security doubly secure?

Mr. BATES. Doubly secure; so that I have in this plan the lake navigation—that is, the lake navigation of the Chagres exactly as in the minority plan, but a little lower. I have also the dam regulation; so that where they have one element of safety I have more.

Senator MORGAN. You have the undersluice there at the Gatun dam, and then you have the dam at Gamboa, and the dam at Alajuela?

Mr. BATES. Yes, sir.

Senator MORGAN. That is three. Are there any other regulation works?

Mr. BATES. There is one at Cano.

Senator MORGAN. Yes; that is for navigation rather than to fence off the waters that come flowing into the prism of the canal, is it not?

Mr. BATES. That is to keep out any possible disturbance from floods or from the watersheds.

Senator MORGAN. Yes. This map, then, is not a correct delineation of your plan?

Mr. BATES. Yes, sir; this is the Panama side; that is Ancon Hill; this is Sosa Hill; these are the islands in Panama Bay; that is the reef, the San Jose rocks; and I call your attention to the fact that in both the majority and minority plans there are channels across this reef.

Their maps, their plans, and the French, all stop at this point, and take no cognizance of this San Jose reef, which I have marked from the latest surveys; so that the alignment given on this plan and on the other one would have to be changed, or they would have to have extra work at this point. Then, at Panama the new town site is mainly made up of Culebra material, that being the most available spoil area.

The literal drift in Panama Bay is such that whatever channels are made out into Panama Bay will be subject to refilling and incessant dredging unless there is a breakwater which cuts it off. Consequently, I would utilize the Culebra material to make these breakwaters. They would have, also, a certain military value.

Senator MORGAN. Are those stone works?

Mr. BATES. Yes, sir. There is a section of the breakwater which is the same as the section of the Plymouth breakwater, in England.

Senator MORGAN. Built of riprap?

Mr. BATES. It is built of various character and sizes of rock. What is called third-class rock forms the core; that is, rock that two men can lift. The second-class rock is rock weighing up to 2 or 3 tons; and first-class rock is rock weighing from 5 to 10 tons, which you put on any exposed surface.

Senator MORGAN. How far is the eastern end of that breakwater from the city of Panama?

Mr. BATES. It is 4 miles.

Senator MORGAN. On the shore, how far is it from the city?

Mr. BATES. From the city of Panama?

Senator MORGAN. Yes.

Mr. BATES. It is about two miles and a half. Two miles and a half either way brings you to the shore ends of the breakwater.

Senator MORGAN. You propose to surround the city of Panama on two sides?

Mr. BATES. All except their water front; it does not interfere with their present water front; and this land that it covers is most of it bare at low tide. I hold that that forms the nearest and safest spoil basin or spoil area for the Culebra spoil.

I would like to add, relative to the sea-level canal, that it does not permit the passage of vessels so readily, and that there is no provision for turning.

(Mr. Bates was thereupon excused, and the committee went into executive session, after which an adjournment was taken until to-morrow, Tuesday, March 13, 1906, at 10.30 o'clock a. m.)

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Tuesday, March 13, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Hopkins, Knox, Ankeny, Morgan, and Taliaferro.

(The following paper, which was submitted by Mr. Bates at the close of yesterday's session and which contains a summary of his views as to the best type of canal to be constructed across the Isthmus of Panama, is, by direction of the committee, printed as a part of the record:)

THE 60-FOOT LOCK AND LAKE CANAL.

Indorsed by the majority of the Board of Consulting Engineers as the best lock and lake canal, page 35. So believed by Mr. Bates with the changes italicized, because:

This canal fulfills, as the 85-foot canal does not, the elementary conditions of safety and adequacy—

1. No head of over 35 feet is impounded by a dam on alluvial foundations.

2. Locks are the full 1,000-foot dimensions.

3. Locks are never in flight, so that the dangers of overrunning are minimized and the divided lock can be used for small ships, saving lockage water.

4. The risks are averaged over many units.

MINDI CANAL ENTRANCE

Atlantic Limon Bay approach half way between Point Toro and Colon giving straight entrance free of reefs to Mindi.

Balboa, a new city to be made opposite Mindi, on the hill between Lake Chagres and the inner salt harbor in Limon Bay.

First lock and low dam making Lake Chagres at 30+ foot level.

Second lock and dam making Lake Gatun-Bohio at 60+ foot level.

By this arrangement the difference in levels or head is but 30 feet. Since dredges can pump up material 35 feet, the dam can be built by them. The locks are separated, not in flight.

The majority plan puts the first lock at Gatun, and the second and summit-level lock at Bohio. But by this latter location only the limited amount of water above Bohio is available for lockage.

The Bates plan puts the second or summit-level lock at Gatun. Thus the full amount of lockage water above Gatun is available, and the first lock at Mindi.

Gamboa sluice dam is proposed to intervene between the upper Chagres floods and the canal at Gamboa. The regulated discharge

passes through the dam sluices and is sent part to the Atlantic and part to the Pacific down the canal.

The majority proposes a 180-foot dam sustaining a deep lake. *Instead of this the Bates proposal is to average the risks over two lower similar dams 117 feet high, sustaining no lake but having behind them basins normally empty to catch the floods.*

At Pedro Miguel the third lock brings the level from that of Lake Gatun-Bohio 60+ feet to that of Lake Panama 26+ feet.

At Ancon Sosa the fourth lock gives the lift between Lake Panama and the Pacific Ocean level.

Greater Panama.—Lake Panama at 26+ foot level makes possible an inner fresh harbor and hill-protected naval station, as at Balboa. It is proposed to use Culebra rock to make great breakwaters, whose heads will be the Panama Harbor islands. Inside these, on the tidal flats, the great central excavation can be deposited to reclaim a greater Panama.

While the decision as to type is being made, the Culebra work necessary for any canal might be done and these breakwaters and reclamation used as the places for disposal of the spoil. This is the only way by which real work can be started at once without the deposited material interfering with the ultimate adoption of any type of canal, for this harbor improvement is incontestably available and desirable or all.

REPORT OF R. L. FARNHAM
CONCERNING PURCHASE OF SHIPS FOR PANAMA RAIL-
ROAD COMPANY, AND PAPERS RELATING
THERE TO.

(The chairman submitted the following papers, which by direction of the committee are printed as part of the record:)

ISTHMIAN CANAL AFFAIRS,
OFFICE OF ADMINISTRATION,
Washington, D. C., March 7, 1906.

DEAR SIR: Referring to the data which your committee asked me to furnish when I was before you yesterday, I have the honor to advise:

First. When the Isthmian Canal Commission purchased the steamers *Havana* and *Mexico* from the New York and Cuba Mail Steamship Company (Ward Line) that company was carrying insurance to the amount of \$425,000 on each steamer, at an average rate of 3.64 per cent. The Panama Railroad Company is now carrying insurance to the amount of \$656,000 on each of these steamers, at an average rate of 3.28 per cent, in favor of the Isthmian Canal Commission, from whom they are leased. These steamers are rated A 1 for twenty years from 1899, the year they were built. This rating was in force when the vessels were purchased from the Ward Line and is still in effect.

Second. I send you herewith copy of the report of survey and inspection on each of the above-mentioned steamers which was made at the time of the transfer from the Ward Line to the Canal Commission.

Third. I send you herewith copy of report made by Mr. E. L. Farnham, dated London, June 2, 1905, and New York, July 15, 1905, concerning his investigation as to the purchase of various foreign ships for the Commission.

Fourth. The cost of the new linen, china, glassware, and silverware purchased for the steamers *Havana* and *Mexico* since their receipt from the Ward Line was \$7,070. Part of the linen, china, glassware, and silverware which we received with the steamers *Mexico* and *Havana* from the Ward Line is being used by the Commission for other pur-

poses, and part of it will be returned to the Ward Line at valuation to be agreed upon as it bears their monogram.

Fifth. I send you herewith copy of the minutes of the meeting of board of directors of the Panama Railroad Company at which the sale of bonds was authorized. These bonds were sold to Mackay & Co., 16 Nassau street, New York, the highest bidders, and repurchased from them as per my testimony of yesterday.

Sixth. No materials have been purchased by the Panama Railroad Company for the Isthmian Canal Commission since February, 1905, except the lot of rails mentioned in my testimony of yesterday, which were purchased in March, 1905. The Canal Commission has purchased its own rails as well as all other material needed by it since that time. No purchases have at any time been made by the Canal Commission for the Panama Railroad. The requisitions for material needed by the Canal Commission are made on requisition blanks headed "Isthmian Canal Commission," and the requisitions for material needed for the Panama Railroad are made on requisition blanks headed "Panama Railroad Company."

Seventh. A statement of material purchased in the open market without advertising since December 1, 1905, is being prepared and will be sent you in a few days.

Very respectfully,

T. P. SHONTS, *Chairman.*

Hon. J. H. MILLARD,

*Chairman Committee on Interoceanic Canals,
United States Senate, Washington, D. C.*

NEW YORK, July 14, 1905.

T. P. SHONTS, Esq.,

*Chairman Isthmian Canal Commission,
24 State street, New York City.*

DEAR SIR: In accordance with your instructions of July 6 we have surveyed and inspected the steamship *Mexico* while lying afloat at pier 18, Brooklyn, and also while in the dry dock at Erie Basin, and beg to advise.

Upon examining the various holds, decks, bulkheads, coal bunkers, and sides of the vessel in same, and the ironwork generally, found the same to be in very good condition and having the appearance of having been well cared for, the only defect found being a slight leak in the margin of the main deck, which requires calking.

The windlass, winches, steering engine, and other deck fittings were found in good order and condition.

The lifeboats and life rafts, together with their fittings, in good order and condition.

The joiner work, deck houses, bridge rails, etc., in good order and condition with the exception of the engine-room skylight cover, which is racked and should be renewed.

The engines and boilers, together with the pumps and the other auxiliary machinery, in good condition.

Upon examining the vessel in the dry dock found the bottom to be in good condition, with the exception that the paint there had been

scraped off in a number of places, but that the plating was free from defects.

The fair-waters over the couplings of the outboard shafting were removed, and upon examining the couplings and also the nuts on the end of the tail shaft found the same to be in good condition.

The shafting and couplings were scraped and painted before replacing the fair-waters.

The propellers, which are of the three-bladed solid bronze pattern, were slightly nicked on the edge of some of the blades, one blade of the port propeller showing a slight crack in same, which we do not consider serious.

The rudder, together with the stern frame, found in good condition.

In view of the above facts, we are of the opinion that this vessel is in good condition for practical service for the balance of her classification life of the hull, machinery, and appurtenances generally, which go to fit a vessel for immediate sea service.

Yours, truly,

HORACE SEE,
FRANK S. MARTIN,
Consulting Engineers and Naval Architects.

REPORT OF SURVEY ON STEAMSHIP HAVANA.

NEW YORK, August 3, 1905.

Mr. E. A. DRAKE,

Assistant to President, 24 State Street, New York.

DEAR SIR: In accordance with your instructions of July 6 we have surveyed and inspected the steamship *Havana* while afloat and also while in the dry dock at Erie basin and beg to advise:

Upon examining the various holds, decks, bulkheads, coal bunkers and sides of the vessel in same, and the ironwork generally, found the same to be in very good condition and having the appearance of being well cared for, the only defect found being a slight leak in the margin of the main deck which requires caulking.

The windlass, winches, steering engine, and other deck fittings were found in good order and condition.

The lifeboats, with one exception, are indented and should be tested in the water for tightness, otherwise they and the life rafts, together with their fittings, are in good order and condition.

The joiner work, deck houses, bridge rails, etc., in good order and condition, with the exception of the engine-room skylight cover, which is racked and should be renewed.

The engines and boilers, together with the pumps and the other auxiliary machinery, in good condition.

Upon examining the vessel in the dry dock found the bottom to be in good condition, with the exception that the paint there had been scraped off in a number of places; the plating, however, was free from defects except above water line, which showed a few indentations. Bottom since then has been thoroughly cleaned and painted.

The fair waters over the couplings of the outboard shafting were removed, and upon examining the couplings, and also the nuts on the end of the tail shaft, found the same to be in good condition with the

exception of starboard shaft, which has been removed and replaced by a spare one.

The shafting and couplings were scraped and painted before replacing the fair waters.

The propellers, which are of the three-bladed, solid bronze pattern, were slightly nicked on the edges of some of the blades.

The rudder, together with the stern frame, found in good condition.

In view of the above facts, we are of the opinion that this vessel is in good condition for practical service for the balance of her classification life of the hull, machinery, and appurtenances generally which go to fit a vessel for immediate sea service.

Yours, truly,

HORACE SEE,

FRANK S. MARTIN,

Consulting Engineers and Naval Architects.

Extract from minutes of meeting of the board of directors of the Panama Railroad Company, held at the office, No. 24 State street, New York, on Wednesday, November 8, 1905, at 11 o'clock a. m.

Present: Messrs. Shonts, Cromwell, Endicott, Hains, Obaldia, Farnham, and Drake.

FINANCIAL CONDITION.

Consideration was given to the necessity for providing means for the payment of the equipment authorized by the board, as well as for other important improvements to the company's property and facilities on the Isthmus which were being undertaken, so as to provide for the prompt, economical, and profitable handling of the large amount of traffic to be expected from the general development of commerce, and the construction of the Isthmian Canal; and the president outlined to the board the many improvements which had been undertaken and which were under contemplation, among them being the construction of new piers at the Atlantic terminus, the extension of existing piers, the installation of modern facilities for the prompt handling of coal and general cargo from steamers, the erection of refrigerating plant, laundry, and bakery, and the construction of an additional pier at La Boca.

The president also explained that during the period of installation of these modern facilities the expenses of conducting the property would, as usual in such cases, increase to a much larger extent than the earnings, and that while the payment of the balance of approximately \$625,000 due to the company by the Isthmian Canal Commission would probably be made in the course of a few months, it would become necessary to provide for the payment of indebtedness already or about to become due.

The president and treasurer made a full report regarding the present financial condition of the company. They advised the board that the Isthmian Canal Commission was unable to pay its indebtedness of about \$625,000 either now or in the immediate future, and that this company had practically exhausted its cash resources in the purchase

of equipment, material, supplies, and for construction, etc., having in hand but \$114,184, which was needed for current operations; that there were overdue accounts for equipment, material, and supplies to the amount of \$208,000, and other accounts of a similar nature falling due within the next sixty days amounting to \$445,000, and that there were still other obligations on account of contracts made and maturing within the next four months, amounting to \$1,132,000; that this condition arose from the extraordinary amount of equipment, supplies, material, and construction which had been made necessary to further the operations of Isthmian Canal Commission in construction of the canal; and that this company had relied upon the Commission to pay its bills, or otherwise to aid the company, but that as the Commission was unable so to do it had become necessary for the company to itself finance its affairs.

They also advised the board that the only available resources of the company were the 628 $4\frac{1}{2}$ per cent bonds in the treasury, and which were created for the very purpose for which the moneys had been expended, viz, for equipment, construction, material, supplies, etc.

It further appeared that the said bonds could by their terms be called in and redeemed by the company on any interest date at 105, so that if the bonds were sold at this time they could be redeemed at 105 on the 1st of next April if the company should so desire. After consideration it was upon motion duly

Resolved, That the executive officers be, and they are hereby, authorized to sell the 628 Panama Railroad $4\frac{1}{2}$ per cent twenty-year sinking-fund gold bonds now held in the treasury at as favorable a price as possible, but not less than 104 $\frac{1}{4}$, the proceeds thereof to be applied to the purchase of equipment and the improvement of the company's facilities.

It was further

Resolved, That upon completion of the sale of the 628 Panama Railroad $4\frac{1}{2}$ per cent twenty year sinking fund gold bonds, above authorized, at not less than 104 $\frac{1}{4}$, the officers be, and they are hereby, directed and authorized to take the proper steps for the listing of same on the New York Stock Exchange; and the committee of securities are hereby requested to remove said bonds from the company's vaults and hand same to the treasurer of the company for delivery to the parties to whom the bonds are sold.

A true copy.

T. H. ROSSBOTTOM,
First Assistant Secretary.

NEW YORK, July 15, 1905.

THEODORE P. SHONTS, Esq.,
President Panama Railroad Company,
24 State Street, New York City.

SIR: I have the honor to submit to you and the board of directors of the Panama Railroad Company the following full report of the mission I was directed to undertake by resolution of the Board at its meeting held on the 16th of May last, which resolution reads:

“Resolved, That Director Farnham be made a general agent of the company, at an appropriate salary to be fixed by the president, and

the latter is hereby authorized to send Director Farnham abroad for the purpose of securing options on two or three vessels of the character required by the company and report the result of his investigations by cable."

Prior to the passage of the foregoing resolution, and considering the pressing requirements of the Panama Railroad Company in respect of its steamship line, the general opinion of the board was that the company needed two or three steamships, preferably twin screws, of approximately 15 knots speed, 5,000 tons cargo capacity, with accommodations for 100 first and 50 second class passengers; and it was to obtain for the company steamships of this type that, acting under the resolution of the board, above recited, and general instructions of the executive committee, I sailed from New York on the steamship *Cedric* on May 19 for Liverpool, where I arrived May 27.

Shipping circles abroad had been advised through the press of my mission, and from the moment of landing numbers of vessels of all sorts were offered by ship brokers and shipowners representing the principal ports of Great Britain and the Continent.

I wish to say that whenever a vessel was submitted that merited consideration, I endeavored to deal direct with the owners; and in all cases, whether agent or owner, I made it clearly understood that no vessel, however desirable it apparently might be, would be purchased by the Panama Railroad Company until it had passed complete inspection in dry dock by both Lloyds and the British corporation. Also that all representations in respect to speed and coal consumption must be corroborated by the submission for inspection of the ships' logs, covering a period of six months' operation. These stipulations caused more or less dissatisfaction and the elimination from consideration of many vessels offered.

Upon my arrival in Liverpool I saw the steamship *Zungeru*, one of the vessels offered for sale. She was just sailing on her regular voyage to the Kongo and I was able only to look her over in a general way. Later, at Antwerp, I completely inspected her sister ship, the *Leopoldville*, also for sale.

These ships I will refer to hereinafter.

From Liverpool I proceeded to London, which is the real center of the shipping business of Great Britain and much of the Continent, and during my stay abroad London was generally my headquarters.

I reached London Saturday night, May 27, and the next three days my entire time, day and evening, was occupied meeting brokers and owners with ships for sale, looking over their memoranda and photographs of the same, and sifting out the most likely ones.

May 30 I went to Newcastle-on-Tyne to see several vessels at the shipyards there, particularly a large new vessel just completed at the yards of the Sir William Armstrong-Whitworth Company. In respect to this vessel I can add nothing to what I reported to you in my letter of June 2 and in subsequent cables, copies of which are hereto attached and made part hereof. Other ships on the Tyne which were to be had I found upon personal inspection so deficient in either speed, passenger accommodations, or size of hatchways, or requiring such alterations in other respects that I dismissed them from further consideration.

Returning to London, I went to see several steamships at the Albert docks and the India docks, among them two steamships of the Union-

Castle Line, formerly in the trade to the Cape of Good Hope, but at that time laid up. Two of these vessels, the *Dunnotar Castle* and the *Arundel Castle*, met—so far as passenger accommodations, cargo capacity, draft, etc., are concerned—the requirements, but their logs showed a speed of 13 to 13½ knots at best, and they are also old ships.

Another vessel of the Union-Castle Line, the *Scot*, which was repeatedly pressed upon me, and I was also told efforts were being made at the same time here to have the company charter her, I found to be as fast as represented (16 knots), but she is a very large coal consumer (about 140 tons a day), and her passenger capacity (over 200 first class), is too great, while her cargo capacity (only 2,600 tons), is too small. She is all machinery and coal bunkers, and I declined to further consider her.

The *Arundel Castle* would have done to charter and I so advised you in my cable of June 11, in which I gave particulars of such vessels as I found suitable for charter.

Other steamships that I went to see were the *Miltiades*, a new ship in the Australian trade and the finest vessel in all respects I saw in London, an ideal vessel for the Panama Company, but too expensive—\$1,000,000; and the steamship *Moravian*, a well-built ship, but rather small and hatches far too small for your purposes.

At Gravesend I went over the Atlantic transport liner *Menominee*, one of three vessels—all alike—offered for sale or charter by that line.

I was aware of the great efforts being made to get one or more of these ships into the employ of the Panama Railroad Company, but, as I reported to you in my letter of June 2, I found the ship too large, too slow, too much refrigerating space, which the Panama Company could not utilize in any way, and the charter price too high to warrant the employment of any of these vessels.

After looking over all the vessels which came nearest the Panama Company's requirements I forwarded to you on the 2d of June, for the consideration of yourself and the board of directors, a report and memoranda respecting these vessels, which is the letter annexed to which I have previously referred.

In respect to the speed desired by the Panama Railroad Company—15 knots—my investigations showed that there were in the market few, if any, vessels with a speed of over 14 knots, except a few fast mail and passenger ships of the type of the *Scot*, above described.

All the largest ship owners and builders told me that a speed above 14 knots meant larger and more expensive boilers and engines and a coal consumption much greater than they considered the ordinary operation of a steamship line on their side warranted. Therefore a greater speed than 14 knots was only to be found in fast mail steamers, or in steamers built for special fast trade. Because of this I submitted to you in my report ships having the best speed obtainable, but all under 15 knots.

Following the mailing of this letter I cabled the company as follows:

LONDON, June 4, 1905.

PANRAILCO, New York.

Per *Lucania* mailed important letters to-day concerning steamships. Believe have found what will be satisfactory. Suggest you arrange with president board of directors for prompt consideration upon receipt

of letter. Desirable under the circumstances decision of the board should be sent me as quickly as possible by cable.

FARNHAM.

On the 5th of June I received from the company at New York the following cable:

NEW YORK, June 5, 1905.

FARNHAM, *Credonais*, London.

In every proposal obtain first, lowest cash price, second, lowest charter rate with longest possible option purchase.

PANRAILCO.

I at once made direct inquiry of owners or agents of all vessels suitable for the company that could be had under charter. Owners, I found, desired to charter on British Government form, which includes with the vessel the crew, maintenance of same, and insurance, the charterer furnishing the coal and paying all port dues. After cleaning up the possibilities of Liverpool, London, Glasgow, Hamburg, and Antwerp, in respect to charters, I cabled you on June 11 as follows:

LONDON, June 11, 1905.

PANRAILCO, *New York*:

In reply to your telegram and as a supplement to my letter the Newcastle ship and *Byron* and *Tennyson* can not be chartered. *Leopoldville Zangeru*, I send a full description by letter, can be chartered at the rate of £3,250 each; other vessels too old to buy, but do for present requirements which can be chartered are as follows: Dimensions are in shipping record; *Arundle Castle*, 4,000 tons cargo; passengers, 75 first class, 50 second; 13 knots on 52 tons coal; price, £2,750. *Cambroman*, 4,200 tons cargo; passengers, 72 first class, 78 second; 13 knots on 70 tons; £2,836. *Vancouver*, 4,000 tons cargo; passengers, 128 first class, 57 second; 13 knots on 75 tons; £2,646. Atlantic transport boats are too large Panrailco's profitable use. All charter prices quoted are payable monthly. Vessel will be delivered here on British Government form, whereby owner provides complete crew, feeds same, and insures ship; you provide coal and pay port dues. Think above charter prices are too high. Cause is generally believed to be eastern war. Many steamships much passenger and little cargo space, charter or sale cheap. Very few ships right proportion of combination Panrailco wants.

FARNHAM.

Meantime, my letter of June 2 had been received by you and considered, and I received the following cable on June 12, delay in delivery being due to a general holiday in England:

NEW YORK, June 10, 1905.

FARNHAM, *Credonais*, London:

Your letters arrived to-day. Committee favorable to purchase Newcastle steamer with conditions of alteration and delivery as reported, but in order to justify submission to President R., must have definite refusal one week on the best terms possible, but under no circumstances exceeding £100,000. Secure and cable definite written refusal.

PANRAILCO.

I at once saw the managing director of the Armstrong-Whitworth Company, Mr. Swan, but he declined to give any refusal for the price offered, or a written refusal at all, except at a price acceptable to his company. Mr. Swan told me that there were other possible purchasers in the market, and his company did not care to tie themselves up for any length of time. He indicated that the lowest price they would consider was £108,000, but I felt satisfied that with authority to offer that as a last resort, and a few days' time, I could drive a better bargain. So I cabled you on June 14 as follows:

LONDON, *June 14, 1905.*

PANRAILCO, *New York:*

Newcastle people absolutely decline to give us refusal at £100,000. Have indicated they will accept £108,000, equal to \$527,000. Believe if authorize me to make bid up to this amount think this price can probably be reduced a little, but can not get refusal steamer at less.

FARNHAM.

You replied to that from Washington on the 15th of June thus:

WASHINGTON, *June 15, 1905.*

R. L. FARNHAM, *Hotel Cecil, London:*

Offer Newcastle people £100,000 sterling flat. If they do not accept get best refusal on *Tennyson* and *Byron*, one ship. American owners Atlantic transport here pressing us on izzard.

SHONTS.

To which I thus replied, after a further conference with Managing Director Swan and the owners of the *Byron* and *Tennyson*:

LONDON, *June 15, 1905.*

PANRAILCO, *New York:*

Newcastle firm absolutely decline offer, say ship cost more. *Byron* *Tennyson* owners have fixed price, two vessels, £155,000. Prefer not selling singly. I think advisable to try offer £80,000 one only, delivery beginning July. Presence other purchasers prevents getting written refusal from all owners except on firm offer from us. Personally think Newcastle ship better value take everything into consideration, even at £108,000 sterling.

FARNHAM.

On the same day I received from you at Washington the following inquiry:

WASHINGTON, *June 15, 1905.*

FARNHAM, *Hotel Cecil, London:*

Have you seen steamers *Port Royal* and *Port Antonio*, owned by Elder Dempster & Co., Liverpool? If so, what is your opinion? If not, investigate and advise.

SHONTS.

I saw by this inquiry respecting the steamships *Port Royal* and *Port Antonio* that the fact that these vessels had been offered to and considered briefly by the company before I sailed had been overlooked. They had been offered again to me in Liverpool, but when I described

our requirements the owners themselves recognized that the vessels were too small.

I also had been informed that misrepresentations in respect to speed, etc., of certain vessels submitted to and rejected by me in London were being made by interested brokers in New York direct to the New York office, and thinking that such statements might mislead, and also replying to your inquiry re *Port Royal* and *Port Antonio*, I sent the following explanatory cable:

LONDON, June 16, 1905.

PANRAILCO, *New York*:

In order that you are to understand situation, there are not many vessels that meet all requirements Panrailco in respect to age, ability carry 4,500 to 5,000 cargo exclusive bunkers, size of holds, hatches, cargo handling, a sufficient amount cabin-passenger accommodations, and upward 13 knots. Other buyers for similar vessels here, and owners will not tie themselves up with option, does not include forfeit and are not certain of sale. If I am able to make firm offer certain sum, can then secure option for a short time if offer is acceptable. Consider *Port Royal* and *Antonio* too small cargo, too slow, too many alterations necessary meet our requirements, and owners here agree with me. Atlantic transport ship is too large, too much draft, too much waste unavailable refrigerator space to make vessels economical, and charter price high. *Byron* due now New York. Almost certain can get option *Byron* alone, but if you want to purchase *Byron* and get delivery before she sails another voyage it will be necessary enable me promptly make definite offer owners here. Consider *Byron* good all-round ship Panrailco purposes, good speed on economical fuel, but considering her age, size, average depreciation, and price, with same features Newcastle ship, think latter, even at their price, best of two for Panrailco. *Byron* as handsome and well finished as Newcastle is homely; poorly finished cabins, but latter will take place of two Panrailco's present ships and carry larger pieces. Outside experts hold same views.

FARNHAM.

The next day I received a cable from the company, the purpose of which I quite understood and which was as follows:

NEW YORK, June 17, 1905.

FARNHAM, *Credionais, London*:

Your instructions were to approximate 5,000 tons cargo capacity ship exclusive bunkers, 15 to 16 knots, side ports, large hatches with corresponding cargo facilities, refrigeration plant, 100 first class, 50 second class passenger accommodations, twin screw preferred. Newcastle good boat, but too slow. Don't waste time on slower than 15-knots boats.

and to which I at once replied—

PANRAILCO, *New York*:

Requirements, instructions, Panrailco fully understood, but no 15-16 knot vessels can be obtained in English, German, or French market, except a few large mail boats, too little cargo and too large passenger capacity; prices upward \$700,000. *Port Kingston* only one can meet

all requirements Panrailco; can be bought probably \$900,000, asking \$1,000,000. Therefore submitted all others nearest suitable. Await instructions before proceeding further.

FARNHAM.

In the meantime I had met some of the larger shipbuilders of Belfast and on the Clyde, who discussed the subject of building such vessels as the Panama Railroad Company desired; and having in mind the suggestion made by several members of the board that while abroad it might be advisable that I ascertain what it would cost to build abroad two such vessels as the company had invited proposals for from American builders, I took up that subject. I had taken with me the same specifications and drawings of a vessel which the Panama Railroad Company had submitted to several shipbuilding firms in the United States, upon which it had asked and received proposals to build two ships.

Hearing also that at one of the yards on the Clyde there was a steamer about completed which might suit the Panama Company, I went to Glasgow for the double purpose of seeing that vessel and seeing some builders in respect to getting proposals for building.

The vessel building, while near what the company desires in respect to passenger and cargo and speed, has too many decks to be useful for carrying anything but small packages of cargo. Small hatches and heights between decks are insufficient to permit the stowing of any large freight.

I visited some of the large shipyards on the Clyde from Glasgow to Greenock; consulted with the builders and obtained from some of the best and largest proposals for the construction of two steamships, which I submit as a separate matter.

While in Glasgow I received the following cable:

WASHINGTON, D. C., June 21, 1905.

FARNHAM, *Hotel Cecil, London:*

Does *Zungeru* approximate our requirements?

SHONTS.

To which I replied:

LONDON, June 21, 1905.

PANRAILCO, *New York:*

Regarding *Zungeru*, refer to my letter of June 2; will not be available until two months; consider these ships relatively dear in view of cargo capacity.

FARNHAM.

I again saw Mr. Swan, of the Armstrong-Whitworth Company at Newcastle-on-Tyne, and two other directors of the company, Mr. Ord and Mr. White, and had a long discussion about their steamship which they had for sale. They explained that they did not feel like making an offer of sale at a lower price than £108,000 without a surety of its being accepted; that if it was rejected they would have only lowered the price against themselves to some other purchaser, but if I was prepared to make a firm offer somewhere between what I had offered and what they had asked a bargain probably could be concluded.

Therefore I cabled you on June 22 as follows:

LONDON, *June 22, 1905.*

PANRAILCO, *New York:*

After conference to-day Newcastle people I think they would seriously consider offer £105,000, including alterations. If you desire to make further offer, instruct by telegraph. If not, think it is advisable I return quickly, and with such complete data all vessels as will enable you to make prompt final decision. Nothing further to be gained remaining here longer. Await telegraphic instructions.

FARNHAM.

And in the absence of any answer I again cabled, on June 25:

LONDON, *June 25, 1905.*

PANRAILCO, *New York:*

What do you think of my suggestion to return? Everything has been sent for your consideration that is likely to suit Panrailco under last price of Newcastle ship. What do you desire me to do?

FARNHAM.

To which I received the following reply:

NEW YORK, *June 27, 1905.*

FARNHAM, *Credonais, London:*

Approve suggestion your telegrams 22, 25 that you return promptly, bringing full data for action here. Advise date sailing.

PANRAILCO.

Meanwhile the owners of the *Zungeru* and *Leopoldville* notified me that the latter vessel had arrived at Antwerp and desired very much that I see her.

I went to Antwerp and spent several hours on the vessel, going all over her. As I wrote you the *Zungeru* and *Leopoldville* are sister ships, and the superficial inspection which I could only give the *Zungeru* at Liverpool was completed when I went over the *Leopoldville*. They are up to date in all respects, saloons beautifully finished, everything first class throughout, but as I said in my report and cable they have not the room in their holds for the sort of cargo that will go to the Isthmus.

The approval of my suggestion to return with all data to enable the board to reach a definite decision, which reached me as above recited on June 28, arrived too late for me to secure return passage before the sailing of the *Deutschland* from Dover July 7, and so I engaged for that steamer, and arrived in New York on the evening of July 13.

I brought with me memoranda of dimensions, carrying capacity, both for passengers and cargo, and details regarding engines, boilers, speed, etc., of a number of vessels, and blueprints and photographs of some, all of which are tendered herewith for your consideration.

Respectfully submitted.

R. L. FARNHAM.

HOTEL CECIL, LONDON, W. C.,
June 2, 1905.

THEODORE P. SHONTS, Esq.,
President Panama Railroad Company,
24 State street, New York City.

DEAR SIR: I herewith report to you for the consideration of yourself and the board of directors of the Panama Railroad Company the results to date of the mission which I was directed to undertake by resolution of the board at its meeting on the 16th of May last.

Pursuant to the general instructions of the executive committee of the company, following the resolution referred to, I sailed from New York on the steamship *Cedric* on May 19, reaching Liverpool May 27 and London on the night of the same day.

Immediately upon my arrival at Liverpool several of the leading ship brokers submitted to me plans and data of a number of steamships which they thought might meet with the requirements of the Panama Railroad Company, which, they understood, desired to charter or purchase two or more steamships for use between New York and Colon. After a conference with the Liverpool brokers in respect to the vessels they offered I came on to London.

I spent nearly all of the first day I was in London (Sunday) in conference with a number of ship brokers who came to see me, bringing plans and specifications of steamships which they had to offer for charter and for sale. The following morning (Monday) I started out to inspect the most promising, for the purposes of the company, of the many vessels offered, and from that time until the hour of writing this I have been constantly busy on this work.

Many ships were submitted which, for one reason or another (either they were too large or too small, or too slow, or their coal consumption too great, or they were freight boats simply), I dismissed from consideration. The vessels which I submit and describe hereinafter appear to be the ones most suited to the requirements of the company. You will recall that among the vessels submitted to the board of directors was a new twin-screw steamship just being finished at Newcastle-on-Tyne, which vessel, from the few details given to the board of directors, appeared to be about the vessel desired, and it is this vessel which I will first report on.

I went to Newcastle and spent an entire day on this steamship. She has been thoroughly gone over by the representatives of Lloyds and has been classed in Lloyds' list 100 A1. I had go over the ship with me an official of the British corporation, the rival organization to Lloyds, and at the end of the day he said of the ship the same that is true of Lloyds' inspector, viz: That in every respect the vessel fully met every requirement of both organizations and of the board of trade in respect to strength of construction, etc., and in many features, particularly in the framing and construction of the hull, she considerably exceeded Lloyds' requirements.

In order that you and the members of the board may better understand my description, I inclose herewith a blueprint of this vessel, and also send back the blueprint (which I brought with me) of the vessel which the company planned to build, in order that you may be able to compare the two. The blueprint of the British ship is loaned by the owners, but I have promised that it will be returned to them as soon as you have considered it. This ship was ordered from the Arm-

strong Company by a London concern, which has been running a line of passenger and cargo boats in the African trade for the last forty years. During her construction this company entered into a traffic agreement with a competing company which obligated them to put no more passenger boats on their line, and as a result they left this ship on the builder's hands, taking in her place a large cargo steamer.

The ship is 435 feet over all; 51 feet 6 inches beam and will draw, fully loaded, 25 feet. She is a great big, exceptionally strongly constructed vessel, with large holds and extra large hatches, and can easily take through these hatches and into No. 2 and No. 3 holes the cars and locomotives which have got to go to the Isthmus. She can carry, exclusive of her coal, 5,400 tons, allowing 1,100 tons of coal in her bunkers. She has a first-class refrigerating plant, with a capacity of 50 tons in her refrigerator; also the necessary apparatus for making ice, sufficient to supply the requirements of the ship. Her twin screws are manganese bronze and the diameter of her shafts is 2 inches more than the specifications require. In respect to her engines and boilers, electric-light dynamos, and auxiliary engine-room machinery (such as pumps, condensers, fans, etc.), the official of the British corporation who was with me said that he considered all of her machinery exceptionally good, and all from the best makers, and, if anything, heavier than is ordinarily put in a ship of the same size.

In respect to coaling this ship I wish to note that she has two coal ports on each side, so that coal may be discharged by chute through the side and directly into the bunkers, a feature not generally found in British ships.

The ship was designed to be turned into an army transport on short notice, and provision has been made on her upper deck for the care of 1,000 troops, and she is well supplied with the necessary bath rooms, lavatories, etc. Her steering gear is of the strongest kind. It is steam gear and so arranged aft that the hand gear, which is inclosed in a steel house, can be connected in a minute's time.

In respect to handling cargo, the vessel has four large cargo booms at each mast, and exceptionally good and large steam winches (four at each mast) for the hoisting work. In fact in every respect as to the hull, size of frames, plating, beams, machinery, steering gear, cargo gear, chains and anchors, the great strength of the vessel is apparent. She is not a handsome boat from the American point of view, but there is no question but that she will carry a big cargo and stand the test of the worst weather she will ever encounter.

As to her speed and coal consumption, the builders will guarantee her to do 15 knots loaded with 4,400 tons and maintain that speed on a six-hour trial trip, using what is called here, North Country coal. In regular work, day after day, fully loaded, and without driving they say she will do 13½ knots, burning about 75 tons a day of Welsh coal, which coal, they say, is about the same as the coal we are using in our steamers. Basing their opinion upon the performances of three other vessels built by them of a similar type, with the same kind of machinery, and using the same kind of coal, the builders tell me they would almost guarantee that after the ship has got her bearings she will do 14 knots regular.

In respect to the passenger accommodations, the ship is not as good as she is in all other features. Like all English vessels her passenger accommodations are amidships. As you will see by reference to the

blueprint, she is well supplied with bathrooms, lavatories, etc. These are all right. Her main saloon is finished in oak, with the upper parts of the sides and the ceiling enamel white touched out with gold. It is a very large, well-lit compartment. The drawing-room and smoking room on the deck above are well fitted, comfortable quarters; the former is finished with a piano, library, etc. The features which I do not like are the staterooms, the captain's quarters, and the absence of a wheelhouse abaft the bridge.

You will see by reference to the blueprint that the staterooms are rather small. Each room contains two berths of white enamel iron, brass finishings, the upper ones made so as to turn up and fasten against the side of the ship. Each stateroom also contains a folding wash basin similar to those on the White Star ships, and also a sofa. The entire finish of the staterooms is white enamel, but the construction is cheap and not at all up to the style and finish of the Ward Line boats. When I spoke of these things to the builders they paid little attention at first, but subsequently asked me what changes would make the vessel more desirable, and when I told them they said that if that only stood in the way of a sale they would make such changes as I suggested.

These changes, briefly, comprise the construction abaft the bridge of a suitable wheelhouse to shelter the helmsman and also any officers whose duty calls them to the bridge; putting a lavatory and bath in the captain's quarters; the changing of the three groups of staterooms on both sides of the ship just abaft the main saloon so as to make 2 staterooms only where there are now 3. This change would give 12 large staterooms in place of the present 18 small ones. With these changes I believe that the ship would well answer the requirements of our company.

The company asks for the vessel, completely equipped for sea in every respect (I have read over the specifications of equipment and they are most complete in all details), and subject to a trial trip, £110,000. The ship has got to be docked, whenever sold, to give her a final coat of paint and to have her top sides painted as well. The builders would make the alterations in the passenger accommodations which I have recited. At the price they ask she would appear to be a big bargain, compared with the cost of a similar ship from American yards, especially in view of the fact that she can be had within two weeks, if the company should decide to purchase her. I believe, however, that if the builders were offered £100,000, flat cash, they would accept it rather than hold the boat for another purchaser, although to-day an agent of the Russian Government made an inquiry for the ship.

I omitted to mention that the ship is supplied with large steel lifeboats, a full complement of sails and storm sails, awnings, hawsers, and mooring gear; that her decks and rails are all teak, and that her propeller shafts are covered into the hull of the ship instead of being held by struts and a collar. Of course, you appreciate the former method is much stronger as well as more expensive.

The vessels which appear next to meet the requirements of the company are the steamships *Byron* and *Tennyson*, sister ships. A description of one covers the other.

These vessels were built in 1900 and will carry 4,000 tons of cargo, exclusive of bunkering. They are 371 feet long, 45 feet beam, and

draw 23½ feet of water. They are single-screw boats and their logs show an average sea speed of 13½ knots on a coal consumption of about 48 tons a day. They have good passenger accommodations for 70 first class and 24 second class, but the latter could well be used for first-class passengers. Both vessels are classed "100 A1" at Lloyds. The hatches of these vessels are somewhat smaller than those of the Newcastle ship, the largest one being 23.5 by 13.4 and the others averaging 18½ by 11.4. The holds are not so deep, and I doubt if we could put into them the largest pieces of freight which have to go to the Isthmus.

Neither vessel has any refrigerating apparatus. Both of them, however, from the specifications shown me here, are strongly constructed ships, boilers and engines first-class, with exceptionally good passenger accommodations—better than our own ships in this respect, and much better finished than are the passenger accommodations of the Newcastle ship. Their cargo-handling facilities are ample, and in all respects both vessels would be better adapted to the requirement of the company—more economical to operate, would carry a larger amount of freight than any of the ships which we now operate, either those belonging to the company or under charter. The only objection of importance is the inability to put steel cars and locomotives aboard them. It might be possible, however, to put a few cars into the No. 2 hold, which is the largest in the ship. These vessels at present are plying between New York and the Rio. One sails from New York on June 5 and the other one will be in New York about June 25.

If the company desired to purchase one or both, they could be delivered at New York in from ten to twelve days after their arrival at that port, which would mean delivery of one of them about the 5th of July and the other one about the 25th of July.

The price asked for both steamers was £160,000, but yesterday the owners indicated to me that they would accept cash for the two ships, delivered in their present condition (physically they are all right, needing only a cleaning and painting outside), £150,000. I inclose you herewith photos and memoranda of these vessels. You will see by these that these ships, as in the case of the Newcastle ship, have their passenger accommodations amidships; also that they are somewhat handsomer looking than the other one, although the other ship is, of course, a much greater carrier and a faster vessel.

Two more vessels out of the many submitted are worth consideration. These are the steamships *Leopoldville* and *Zungeru*. These vessels are both alike; one year old, and will carry about 3,800 tons, exclusive of bunkers. The *Zungeru* I saw at Liverpool, where she was just sailing for South Africa. The *Leopoldville* is due at Southampton on the 25th instant, and, after discharging, would be available if desired. The owners were to furnish me with a blueprint plan of the ship, but up to the hour of mailing this letter it has not reached me. I may say, however, that in general appearance these vessels resemble the larger vessel at Newcastle, but, of course, considerably smaller. As you will see by the memoranda which I inclose in respect to these ships, their speed is given at 13½ knots on a coal consumption of 55 tons a day. They have accommodations for 83 passengers first class and 64 second.

So far as construction goes and equipment of machinery, both for propelling the ship and for handling cargo, these vessels meet every

requirement. Their hatches, as you will observe, are not over large, judged by our ships, but their No. 2 hold is a pretty large compartment and I think would carry some pretty big pieces of machinery. These vessels have twin screws with bronze blades, and all of their auxiliary machinery is of the most up-to-date character. They are supplied with refrigerating plant, but the capacity of each ship in this respect is limited to about 20 tons; simply enough to take care of the requirements of the ship itself on board. While the price asked for these vessels is £90,000 each, and every time that I have suggested a lower price I have received emphatic refusal to consider the same; nevertheless, I believe that £85,000 cash offer would get the vessel.

I have named the vessels herein submitted to you in the order which they appear to relatively meet the requirements of the company.

Out of all that have been offered these five seem best suited to the New York-Colon business. Three boats have also been submitted for charter by the Atlantic Transport Company, and I send you herewith inclosed a memorandum in respect to their size, passenger accommodations, etc., together with the price asked. In respect to the latter, the term "Government form" as used here means with full crew aboard, so that for the price quoted you would get ship and crew, but even so it seems a great deal of money to pay for these ships. While the memoranda which I send does not so state, each vessel is supplied with refrigerating capacity for about 1,500 tons. One of these vessels—the *Menominee*—is here at London, where I have seen her. She appears almost too large for the service, but of course has large carrying capacity, with a speed about the same as the steamers we are now operating.

I have not been able to obtain any satisfactory quotations for chartering the steamers *Byron*, *Tennyson*, *Leopoldville*, and *Zungern* from their respective owners. Representatives of the Russian Government are here talking with owners and brokers in respect to chartering vessels of the type of the ones above mentioned and the result is that vessel owners at the present time have very high ideas in respect to charter prices. The Union-Castle Line have two boats which would suit the company quite well if they could be chartered at a reasonable price, but this company refuses absolutely to charter its vessels and the vessels which it would be desirable to charter are too old to buy.

I would say, in conclusion, that I have thoroughly investigated every vessel which it appeared might possibly meet the requirements of the company, and in so doing have covered every principal ship building and shipping port of Great Britain. Several German vessels and one French vessel have been submitted, but they are all too large and too expensive for your requirements.

The vessels which I herein submit for your consideration I have fully looked into, both through Lloyds and the British corporation, and feel satisfied that each and all will prove as represented.

I shall await further instructions from the company after consideration has been given to this report.

Very truly,

R. L. FARNHAM.

LONDON, June 4, 1905.

PANRAILCO, *New York*:

Per *Lucania* mailed important letters to-day concerning steamships. Believe have found what will be satisfactory. Suggest you arrange with president board of directors for prompt consideration upon receipt of letter. Desirable under the circumstances decision of the board should be sent me as quickly as possible by cable.

FARNHAM.

LONDON, June 11, 1905.

PANRAILCO, *New York*:

In reply to your telegram and as a supplement to my letter, the Newcastle ship and *Byron* and *Tennyson* can not be chartered. *Leopoldville* and *Zangeru*—I send a full description by letter—can be chartered at the rate of £3,250 each. Other vessels—too old to buy, but do for present requirements—which can be chartered are as follows (dimensions are in Shipping Record): *Arundle Castle*, 4,000 tons cargo; passengers, 75 first class, 50 second; 13 knots on 52 tons coal; price, £2,750. *Cambroman*, 4,200 tons cargo; passengers, 72 first class, 78 second; 13 knots on 70 tons; £2,836. *Vancouver*, 4,000 tons cargo; passengers, 128 first class, 57 second; 13 knots on 75 tons; £2,646.

Atlantic transport boats are too large Panrailco's profitable use. All charter prices quoted are payable monthly. Vessel will be delivered here on British Government form, whereby owner provides complete crew, feeds same, and insures ship; you provide coal and pay port dues. Think above charter prices are too high. Cause is generally believed to be Eastern war. Many steamships—much passenger and little cargo space—charter or sale cheap. Very few ships right proportion of combination Panrailco wants.

FARNHAM.

LONDON, June 14, 1905.

PANRAILCO, *New York*:

Newcastle people absolutely decline to give us refusal at £100,000. Have indicated they will accept £108,000, equal to \$527,000. Believe if authorize me to make bid up to this amount think this price can probably be reduced a little, but can not get refusal steamer at less.

FARNHAM.

LONDON, June 15, 1905.

PANRAILCO, *New York*:

Newcastle firm absolutely decline offer. Say ship cost more. *Byron* *Tennyson* owners have fixed price two vessels £155,000. Prefer not selling singly. I think advisable to try offer £80,000 one only, delivery beginning July. Presence other purchasers prevents getting written refusal from all owners except on firm offer from us. Personally think Newcastle ship better value take everything into consideration, even at £108,000 sterling.

FARNHAM.

LONDON, *June 16, 1905.*PANRAILCO, *New York:*

In order that you are to understand situation, there are not many vessels that meet all requirements Panrailco in respect to age, ability carry 4,500 to 5,000 cargo exclusive bunkers, size of holds, hatches, cargo handling, a sufficient amount cabin passenger accommodations and upward 13 knots. Other buyers for similar vessels here, and owners will not tie themselves up with option, does not include forfeit and are not certain of sail. If I am able to make firm offer certain sum, can then secure option for a short time if offer is acceptable. Consider *Port Royal* and *Antonio* too small cargo, too slow, too many alterations necessary meet our requirements, and owners here agree with me.

Atlantic Transport ship is too large, too much draft, too much waste unavailable refrigerator space to make vessels economical, and charter price high. *Byron* due now New York. Almost certain can get option *Byron* alone, but if you want to purchase *Byron* and get delivery before she sails another voyage it will be necessary enable me promptly make definite offer owners here. Consider *Byron* good all-round ship Panrailco purposes, good speed on economical fuel, but, considering her age, size, average depreciation and price with same features Newcastle ship, think latter even at their price best of two for Panrailco. *Byron* as handsome and well finished as Newcastle is homely, poorly finished cabins, but latter will take place of two Panrailco's present ships and carry larger pieces. Outside experts hold same views.

FARNHAM.

LONDON, *June 17, 1905.*PANRAILCO, *New York:*

Requirements, instructions, Panrailco fully understood, but no 15-16 knot vessels can be obtained in English, German, or French market, except a few large mail boats, too little cargo and too large passenger capacity; prices upward \$700,000. *Port Kingston* only one can meet all requirements; Panrailco can be bought probably \$900,000; asking \$1,000,000. Therefore submitted all others nearest suitable. Await instructions before proceeding further.

FARNHAM.

LONDON, *June 21, 1905.*PANRAILCO, *New York:*

Regarding *Zungeru*, refer to my letter of June 2. Will not be available until two months. Consider these ships relatively dear in view of cargo capacity.

FARNHAM.

STATEMENT OF WILLIAM BARCLAY PARSONS
BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.

LONDON, *June 22, 1905.*PANRAILCO, *New York:*

After conference to-day Newcastle people I think they would seriously consider offer £105,000, including alterations. If you desire to make further offer, instruct by telegraph. If not, think it is advisable I return quickly and with such complete data all vessels as will enable you to make prompt final decision. Nothing further to be gained remaining here longer. Await telegraphic instructions.

FARNHAM.

LONDON, *June 25, 1905.*PANRAILCO, *New York:*

What do you think of my suggestion to return? Everything has been sent for your consideration that is likely to suit Panrailco under last price of Newcastle ship. What do you desire me to do?

FARNHAM.

NEW YORK, *June 5, 1905.*FARNHAM, *London:*

In every proposal obtain, first, lowest cash price; second, lowest charter rate, with longest possible option purchase.

PANRAILCO.

JUNE 15, 1905.

FARNHAM, *Hotel Cecil, London, W. C.:*

Have you seen steamers *Port Royal* and *Port Antonio*, owned by Elder, Dempster & Co., Liverpool. If so, what's your opinion. If not, investigate and advise.

SHONTS.

JUNE 21, 1905.

FARNHAM, *Hotel Cecil, London:*

Does *Zungern* approximate our requirements.

SHONTS.

JUNE 27, 1905.

FARNHAM, *Credonais, London:*

Approve suggestion your telegrams 22-25 that you return promptly, bringing full data for action here. Advise date sailing.

PANRAILCO.

STATEMENT OF WILLIAM BARCLAY PARSONS.

Senator KITTREDGE. Mr. Parsons, will you state your name and age?

Mr. PARSONS. William Barclay Parsons. My age is 47; at least, I will be 47 next month.

Senator KITTREDGE. Where do you live?

Mr. PARSONS. I live in the city of New York.

Senator KITTREDGE. What is your profession?

Mr. PARSONS. Civil engineer.

Senator KITTREDGE. How long have you followed that occupation?

Mr. PARSONS. Twenty-five years.

Senator KITTREDGE. Will you state very briefly your professional record and experience.

Mr. PARSONS. I graduated from the School of Mines of Columbia University, having previously graduated from Columbia College. Then, after an experience in coal mining and railroad construction, I entered the service of the Erie Railroad, where I was for several years. Then I went to New York and began the practice of my profession as a consulting engineer, and engaged in work in different parts of the United States.

In 1891 I was made deputy chief engineer of the rapid transit commission, and in 1894 chief engineer of the present commission, which office I held until the end of last year, on the completion of the subway.

The present subway in New York was planned and constructed under my direction.

Incidentally to that I was chief engineer of what is known as the American Railway in China, and made surveys for that; I was also advisory engineer to the royal commission on London traffic, a member of the Isthmian Canal Commission, and a member of the Board of Consulting Engineers.

Senator KITTREDGE. You were appointed a member of the Canal Commission about two years ago?

Mr. PARSONS. About two years ago.

Senator KITTREDGE. And you continued in that capacity until last April?

Mr. PARSONS. Until last April—the 1st of April.

Senator KITTREDGE. On what committee of that Commission did you serve?

Mr. PARSONS. I was a member of the committee on engineering and chairman of the executive committee.

Senator KITTREDGE. As a member of the committee on engineering, what attention did you give to the engineering questions presented by the construction of the canal at Panama?

Mr. PARSONS. I gave very close attention to the engineering problems for the year that I served on the Commission, and wrote, with Professor Burr and General Davis, the report of the engineering committee.

Senator KITTREDGE. Do you refer to the report of February a year ago?

Mr. BATES. The report of February a year ago.

Senator KITTREDGE. You were a member of the Board of Consulting Engineers appointed by the President?

Mr. PARSONS. I was.

Senator KITTREDGE. And served in that capacity?

Mr. PARSONS. I did.

Senator KITTREDGE. And signed the majority report?

Mr. PARSONS. I did.

Senator KITTREDGE. In favor of a sea-level canal?

Mr. PARSONS. I did.

Senator KITTREDGE. Have you read the report of the minority members of the Board of Consulting Engineers?

Mr. PARSONS. I have.

Senator KITTREDGE. Have you read the statement of Mr. Stevens, the chief engineer of the present commission?

Mr. PARSONS. I have.

Senator KITTREDGE. What engineering questions are you now generally interested in—what great works?

Mr. PARSONS. I am consulting engineer for the various transportation companies constructing lines in New York—the Interborough Company, the Hudsons companies, the New York and Long Island Railroad Company, building a tunnel beneath the East River; I am drawing the plans for the Cape Cod Ship Canal, and some other works. Those are the principal works.

Senator KITTREDGE. Have you had experience in the work of constructing dams?

Mr. PARSONS. I have. I designed the Sparrows Falls dam across the Hudson River, just above Glens Falls, damming the valley of the Hudson with a length of 2,500 feet and a height of 100 feet above the bottom of the river, and excavated to a depth of 60 feet below the bottom of the river, making a total height of dam of about 150 feet, all of masonry.

Senator KITTREDGE. When was that work performed?

Mr. PARSONS. That work was finished about two years ago.

Senator KITTREDGE. Now, Mr. Chairman, I think that the proper foundation for the witness to testify has been laid.

The CHAIRMAN. Yes, and I think it would perhaps be better for Mr. Parsons to give us now his views of the minority report in this case. I will ask you to go on, Mr. Parsons, and give us your views generally of the report of the minority. We of course know your views in regard to the majority report, and if you would be kind enough to give us, in a general way, your views of the minority report we will be glad to hear them. You are familiar with it, of course. If you have not a copy we will furnish you one, and you can have it before you.

Senator KITTREDGE. Before you begin, Mr. Parsons, I would like to call your attention in that connection to a statement made by Mr. Bates on Saturday, as I recollect, to the effect that while the report of the minority gives the usable dimensions of the locks at Gatun as 900 feet by 95 feet, in fact they are less than 800 feet—790 feet, as I recollect the exact distance. I would like to call your attention to that statement and ask you, during your statement, to comment upon that, if you will.

Senator MORGAN. The statement is printed. You had better get the exact terms of it.

The CHAIRMAN. Mr. Parsons has it before him, I think.

Mr. PARSONS. The testimony of Mr. Bates to which you have referred, Senator, is the last testimony that I have received from the committee, and I noticed the statement. You will find it on page 1639.

Senator KITTREDGE. Will you not please read the statement? I may have inaccurately quoted it.

Mr. PARSONS. Mr. Bates, reading from his written statement, stated as follows:

“The minority’s dangerously conjoined three Gatun locks are stated to have usable lengths of 900 feet. These lock lengths are 790, 790,

and 820 feet on the official plans they have themselves put out, and which are indorsed by the Commission and the Secretary of War."

Mr. Bates then proceeded, apparently from the testimony, to show to the committee a model or plan that he had prepared, showing the largest Cunarder (a vessel which is now actually in construction) placed in one of these locks, showing that it would be practically impossible to take that ship in the lock.

I will answer that question, Senator, in the course of my remarks. The CHAIRMAN. The pamphlet handed you just now is Mr. Bates's testimony of yesterday. You have it all now.

Mr. PARSONS. Thank you very much, Senator. This, of course, I have not seen.

The CHAIRMAN. Yes; the other you have. That was the testimony of Saturday.

Mr. PARSONS. Saturday's testimony I had seen. Yesterday's testimony, of course, I had not seen.

The minority plan, as the committee is aware, Senator, describes a canal with a summit level at 85 feet above mean sea level, reached by a flight of three locks on the Atlantic side, the three locks being placed in flight at Gatun; and reached from the Pacific side by two sets of locks, two locks in flight on the Pacific shore near Sosa and one at Pedro Miguel.

The plan that the minority has submitted is, in my judgment, a feasible scheme. It can be constructed; it can be constructed probably within the limit of cost and time that the minority has set forth. If it was to be regarded as simply a commercial enterprise by a private corporation that would have to go into the open market and risk its capital and pay for that capital 5 or 6 or possibly 4 per cent, when commissions and discounts are taken into consideration, and then expect to make a profit over and above that 5 or 6 per cent, I should say that the plan as prepared by the minority would be a perfectly satisfactory plan. It probably represents the least cost at which a canal can be constructed across the Isthmus of Panama. But that is not the case that was presented to you. This is not a canal to be built by a private corporation; it is a canal to be built by the United States Government.

The United States Government, in the first place, instead of having to pay 5 or 6 or more per cent for its money, can borrow it at, say, 2 per cent. The fixed charges are, therefore, reduced to one-third.

Second, the United States Government seeks for no profit.

Third, the United States Government is looking not only to the safety of the vessels, but to the safety of the canal itself. It must be a canal in which not only the accidents to the vessels are reduced to the minimum, but in which the accidents to the canal itself are reduced to the minimum, so that this canal can be used not only in the ordinary course of commerce, but used in the extraordinary circumstance of war; and, in my judgment, the plan as proposed by the minority does not meet those requirements.

The locks themselves are a source of danger in operation. They are a source of delay in operation. They present vulnerable points for attack in case of war, and they make a canal that is practically inelastic. In other words, that can not be increased in usable dimensions except at a very great cost.

That, in a few words, is my criticism of the minority report.

The CHAIRMAN. Would not the same thing apply to both types of canal if you wanted to change it? Either one of them could be changed only at great cost, could it not?

Mr. PARSONS. No; because the sea-level canal is a canal that would not have to be changed. It is the ultimate development. You have gotten down then to the lowest possible point; you can not go any farther.

The CHAIRMAN. You think the plan as submitted by the majority would require no change?

Mr. PARSONS. The plan submitted by the majority would require no change. If at any time the demands of commerce or the growth of ships became so great that a larger canal (which would be merely a wider canal) would be required, the canal of course could be widened gradually and without interference with traffic, exactly as they are now doing with the Suez Canal. Of course you must remember, however, that the Suez Canal, even after being widened and deepened, will not have the dimensions, either as to width or depth, that have been proposed by the majority for the canal at Panama.

Senator DRYDEN. Do you consider that the flights of locks as provided by the minority are dangerous or impracticable?

Mr. PARSONS. I consider them exceedingly dangerous, Senator.

Senator DRYDEN. You think that the machinery is liable to get out of order so that there will be difficulty in operating the locks?

Mr. PARSONS. It is not merely the question of machinery; it is the question of human fallibility. Take the Manchester Canal, for instance. There have been three cases in the history of that canal where vessels have actually gone through a lock.

Senator DRYDEN. Gone through? You mean where they have broken it down?

Mr. PARSONS. They have broken it right down—charged and gone through; and the day will come at Gatun—it may not come the first year, it may not come for ten years, it may not come for twenty years, but that it will come I do not think there is the slightest doubt—when some steamer will go plunging down that ladder.

Senator DRYDEN. And the effect of that would be to put the locks out of business for a long time?

Mr. PARSONS. The effect of that would be to put the canal out of business for a period of anywhere from one to five years. In other words, you would have to rebuild the locks; you would have to refill the lake; you would have to reconstruct the channel below the locks, to say nothing of the damage that would result from such an accident.

Senator DRYDEN. I understood you to say that such an accident would delay the use of the canal for from three to five years, possibly?

Mr. PARSONS. Probably. You would have to reconstruct the canal.

To show you how those accidents occur in spite of care, one of the accidents that happened in the Manchester Canal—

Senator MORGAN. That is one of the two you mentioned?

Mr. PARSONS. That is one of the three I mentioned, Senator—one of those accidents was where a vessel was approaching a lock with a strong gale astern. The pilot on the bridge rang, as usual, to stop. He supposed he had allowed enough for the gale. He found that the gale was pushing him into the lock a little faster than he had allowed for, so he rang to the engine room to back. He found that the engine

room was not backing hard enough, so he rang a third time, "Astern full speed."

Now, the man in the engine room, not knowing what was taking place on top, looked for the natural sequence of orders—first to stop, then to back, which frequently happens. Then, having backed, and believing that his ship was going astern, he looked the next time for an order to go ahead. His bell rang, and, as he expected, the indicator was "Half speed ahead." So he gave his vessel half speed ahead. The pilot on the bridge, realizing that the vessel was going ahead instead of going astern, rang again "Full speed astern." The vessel did not stop its speed, and went plunging through the gates. The wire leading from the bridge to the engine room had parted at the critical moment of the third signal, and instead of indicating in the engine room "Full speed astern," it indicated "Half speed ahead," and the ship went plunging through the gates.

In that particular case, as in the other two cases—

Senator MORGAN. What was the result?

Mr. PARSONS. I was just going to give that, Senator. In that case, as in the other two cases, the attendants on the shore, seeing that the vessel was going to strike the lower gates and was bound to go through, stood ready and started to close the gates just as the stern of the vessel passed the upper gates. The rush of water as the vessel carried away the lower gates brought the two upper gates together with a bang, sufficient to wreck the gates, but not sufficient to tear them away; so that the gates, fortunately for the lower regions of the canal, held back the water in the upper level. The lock itself was out of service for something like a month, while new gates were being put in place.

In that case the gates had a lift of some 13 feet only, and a width of lock of about 70 feet. In the case in question, with gates lifting 30 odd feet and with a width of 95 feet, with the corresponding increase in weight of gate and enormously increased pressure of water, it is practically certain that no gate could be built that could be operated under ordinary conditions that would stand the bang of those gates coming together.

Senator MORGAN. Mr. Parsons, did I understand you to say that a gale was blowing at the time?

Mr. PARSONS. A gale was blowing at the time.

Senator MORGAN. Let me ask you, right there—the dam at Gatun would be about how far from the shore?

Mr. PARSONS. Five or 6 miles.

Senator MORGAN. How far from the shore of Panama Bay would the lock gate be?

Mr. PARSONS. Right at the shore, on either plan—either the sea-level plan or the other plan.

Senator MORGAN. In the case of a gale blowing home on either of those waters, would there not be very serious danger of breaking down the locks in one case, the case of the Bay of Limon, and breaking down the lock gate in the other case?

Mr. PARSONS. I think there is always a danger of breaking down a lock gate.

Senator MORGAN. Now, if you add to a gale some uplift of the sea, such as has frequently occurred on the Pacific coast there by what we call a tidal wave, caused by an earthquake or volcanic action, or whatever the action may be that causes it, we do not quite know, would

not that endanger the lock gate on the Panama side and also the canal itself? If a tide should be blown in by a gale, and also uplifted by some volcanic or seismic disturbance at the same time, would there not necessarily be a very hazardous and very destructive operation upon the canal and the lock gates?

Mr. PARSONS. The lock gates, of course, would be built sufficiently high to cover any known or probable contingency that would arise at Panama, so that they would be above the level of water in any possible case. But suppose that you got an extraordinary tide from some volcanic action in the Pacific Ocean, and a tidal wave came along that coast. The result would simply be that the gates would be topped, would be drowned out, and the back country flooded; and when the tide went down your conditions would become normal again, except so far as the City of Panama was concerned. It, of course, would be washed out.

Senator MORGAN. Those contingencies are among the possibilities of the situation.

Mr. PARSONS. Those contingencies, of course, are among the possibilities of any situation.

Senator MORGAN. Except on the top of a mountain? You would not expect the sea to invade the top of a mountain?

Mr. PARSONS. No; but I mean on the ocean shore.

Senator MORGAN. On the ocean shore?

Mr. PARSONS. You are liable, of course, to get a tidal wave such as they had at Lisbon a great many years ago, or on the Chilean coast a great many years ago; there was a tidal wave there.

Senator MORGAN. I understand from the hydrographic surveys that the "northwesters," as they are called down there, blow home in the Bay of Limon frequently, annually?

Mr. PARSONS. They do.

Senator MORGAN. And sometimes very heavy seas roll in there, caused by atmospheric disturbances two and three hundred miles away from the coast?

Mr. PARSONS. They do.

Senator MORGAN. Those have to be taken into consideration in locating locks in the canal within reach of their influence, do they not?

Mr. PARSONS. They do.

Senator MORGAN. Just as on the other side the seismic disturbances and the gales that may blow into the Bay of Panama have to be considered? Both sides have to be protected?

Mr. PARSONS. Both sides have to be taken care of.

Senator MORGAN. They are matters that we have to consider in establishing a canal if we expect it to be a permanent establishment?

Mr. PARSONS. I think that the Limon Bay situation has been taken care of by the jetties that have been proposed.

Senator MORGAN. You think that is sufficient?

Mr. PARSONS. I believe that is sufficient. I have seen, myself, Senator, one of those gales rolling in there.

The report of the Isthmian Canal Commission, or the Walker Commission, as it was called (that is, the Commission previous to the present Commission), that was sent down there to examine and report, and that reported in favor of an 85-foot level, made no provision for any protection in Limon Bay. I believe that the first real calling attention to the needs of protection at Limon Bay was made by the report

of the engineering committee of the present Commission before it was reorganized—the report of February, 1905, in which Professor Burr and General Davis and myself advised the protection of the approach to the canal in Limon Bay.

As laid out by the French, and as approved by the Walker Commission, the entrance to the canal came in from the open, as you can see on that map, and then turned around the point of Colon, and then entered the canal itself back of that point. While Professor Burr and I were with General Davis on the Isthmus in January and February a year ago, one of the periodic “northers” came along, and we started at once for Colon to see its effects. It was the most severe gale they had had, I think, in some three years. It was so severe that every steamer in the port of Colon went to sea for safety. It was impossible for a vessel to lie in the harbor of Colon, and the steamers went to sea and did not come back for some four or five days. They went up the coast and into the harbor of Porto Bello and took refuge there, and waited for the storm to blow out.

The seas were rolling so high in Limon Bay at that time that it would have been practically impossible for any vessel to have entered the canal, or still more so for any vessel to have doubled Colon Point and made the right-angle turn there and gone into the canal. In coming broadside on to the wind, as she would have done, her stern would undoubtedly have swung off, so that she would have gone ashore on one side of the canal channel or the other, for that would have to be a dredged channel at that point.

We determined then that it would be unsafe to follow the French plans or the plans of the Walker Commission and leave Limon Bay unprotected, and we therefore recommended that a system of breakwaters be established. That recommendation was developed by the Board of Consulting Engineers, and both the majority and the minority agreed substantially on the same lines of protection.

Senator MORGAN. And that they are sufficient?

Mr. PARSONS. And that they are sufficient.

Senator MORGAN. Now, I want to make a little comparison. Have you ever been at Port Said?

Mr. PARSONS. Never.

Senator MORGAN. Or Suez?

Mr. PARSONS. No; I regret that I have not.

Senator MORGAN. You have studied the question of the protection that is given there, however?

Mr. PARSONS. I have, sir.

Senator MORGAN. At Port Said has the protection been sufficient at all times?

Mr. PARSONS. I understand that it has been.

Senator MORGAN. And yet they have heavy storms in the Mediterranean?

Mr. PARSONS. They have very heavy storms in the Mediterranean.

Senator MORGAN. Very heavy. They also have heavy storms in the Red Sea?

Mr. PARSONS. They have.

Senator MORGAN. But the protection given at Suez and also at Port Said has been found to be sufficient?

Mr. PARSONS. It has.

Senator MORGAN. At all times?

Mr. PARSONS. And the protection that is proposed by the Board of Consulting Engineers, practically unanimously, for Limon Bay was developed with the aid of Mr. Quellenec, the consulting engineer of the Suez company, in the light of their experience at that point.

Senator MORGAN. Have the majority of the Consulting Board arranged any breakwater or any system of protection against these incoming storms and seas on the Panama side?

Mr. PARSONS. Nature has done that. The chain of islands that you can see on this map protects the mouth of the canal. There has been no storm known there since the Isthmus has been used as a means of transit that has made it impossible for vessels to lie there.

Senator MORGAN. And that chain of islands protects it sufficiently?

Mr. PARSONS. It protects it sufficiently.

Senator MORGAN. Both the anchorage outside of or in the midst of those islands, and the entrance to the canal?

Mr. PARSONS. And the entrance to the canal. Those islands practically form a breakwater in case of a storm in the Pacific, and storms are very rare on the Panama side. In fact, in that latitude the big storms come from the north, so that the Isthmus itself breaks the storms on the Panama side. At the time of this storm that I am referring to the Pacific Ocean was quite calm. There was no storm on the Pacific side, and we did not really appreciate the storm until after we got over the top of the divide.

Senator MORGAN. So that you consider the situation on the Panama side as being practically sufficient to guard the vessels at anchor and also the inlet to the canal?

Mr. PARSONS. I do.

Senator MORGAN. That is all I want to ask you upon that point.

Mr. PARSONS. Now, if I may answer Senator Kittredge's question in regard to the locks at Gatun, I think I can explain Mr. Bates's criticism.

This sheet that I lay before you is Plate XI of the report of the Board of Consulting Engineers, in which you will see the Gatun dam and the three locks in flight.

Senator MORGAN. Before you leave that matter, there is just one thing that I want to ask you that escaped me in this examination. Do you think it is practically safe to enter the Bay of Colon, we will call it, in times of storm at sea, and turn that curve that you describe as a right angle, and come into the interior bay at Colon?

Mr. PARSONS. In there [indicating]?

Senator MORGAN. Yes.

Mr. PARSONS. I think it would be. I think it would be, because any sea that comes rolling past the mouth of the breakwaters, coming in, as you will see by the map, into a bell mouth, would be sufficiently dissipated by the time it got to Cristobal Colon Point to permit a vessel to double that point if it wanted to.

Senator MORGAN. That breakwater there extends to the 40-foot contour?

Mr. PARSONS. That goes out to 40 feet of water.

Senator MORGAN. Yes; out to 40 feet of water. Is it 40 feet?

Mr. PARSONS. It is 42 feet, as a matter of fact, I think. I think it goes out to the 7-fathom line.

Senator MORGAN. Does the breakwater, as projected by the majority

of the Board of Consulting Engineers, afford protection also to the Bay of Colon?

Mr. PARSONS. Yes; because here is the roadstead where the vessels anchor. Here, as you see by the map, are the piers of Colon; and it would be along on the shore and in behind Cristobal Colon Point that the business would be done.

Senator MORGAN. So that in the event of opening the canal into the bay of Limon, 4 or 5 miles farther down the coast than Colon, we would by that breakwater also protect to a considerable degree the Bay of Colon, so that it could be kept open for the benefit of Panama and for mercantile resort?

Mr. PARSONS. It could be; in fact, you would make it a port.

Senator MORGAN. Yes.

Mr. PARSONS. You would make it a port. It is not a real port to-day, because, under certain conditions of weather, such as I have just described (which I myself have seen), a vessel can not lie there. There were five steamers in port at the time; and, as I said, all five had to go to sea. They could not stay in there. They had to go to sea for safety.

Senator MORGAN. That answers all the questions I wanted to ask.

Senator DRYDEN. Did not Mr. Bates criticise the situation there with regard to the depth of the water and also the projecting rocks underneath the water?

Mr. PARSONS. Mr. Bates preferred his own method of making a harbor, which was to wholly abandon Colon and build a new city back on the shore here, the south shore of Limon Bay, and put in a breakwater, and then construct a new harbor inland by large excavation.

Senator DRYDEN. He did not approve the arrangement of the breakwaters as proposed by both the majority and the minority engineers?

Mr. PARSONS. He did not.

Senator DRYDEN. You still, of course, adhere to your views on that point?

Mr. PARSONS. The board was quite unanimous on that point.

To answer Senator Kittredge's question, as I said a moment ago, I lay on the table Plate XI of the report of the consulting engineers, showing the Gatun dam and the series of three locks; these locks being included between the three shaded lines here, which represent the outer walls and the inner wall separating the twin locks.

When the advocates of the lock canal brought forward a scheme of locks in flight, it was opposed by the majority members of the board on the score of safety. It was said that a vessel might come through there, and if she happened to carry away the upper gates—did not stop at the upper gates—she would undoubtedly go right down through the succeeding locks and carry the whole thing away, drain off the lake, and destroy the canal from Gatun into the sea.

Senator KITTREDGE. That would entirely destroy the canal as far as use was concerned?

Mr. PARSONS. As far as use was concerned the whole canal, of course, would be out of service until the new gates could be restored here and Gatun Lake refilled. The filling of that lake would take something over a year.

The advocates of the lock canal met that point by stating that they could put in some special kind of a gate that could be closed in case of an emergency, as was actually done at Manchester. The objection

to that was, of course, that any emergency machinery is liable to get out of order; any machinery which is called into use once in ten or fifteen or twenty years, or longer, is almost certain not to be ready when it is called for.

Senator KITTREDGE. What about this emergency machinery? Was any particular type suggested?

Mr. PARSONS. No. They said that some sort of a gate could be devised that could be quickly floated into place and that would be sufficiently strong to stand the great shock of closing with a bang.

Senator KITTREDGE. Were any suggestions made as to the possibility of constructing machinery of that sort?

Mr. PARSONS. As you will see here in a moment, they did not propose it in detail. Nothing of that sort has ever been done—to close a gate with any such head as that.

The minority came to the conclusion that the best thing to do would be to install double gates at each one of these locks, and have two gates always open in front of a ship and close behind it, so that the emergency machinery would be put into service every time a vessel went through, which, of course, is a much safer procedure. It would involve, possibly, a slight delay in opening and closing the gates, as two sets of gates would have to be opened, but that, I think, would be a negligible quantity.

Their argument was that if a vessel came down under way and struck the upper gates she would carry away the first gates, but that she would still have in front of her a second pair of gates, which, under any ordinarily conceivable condition of affairs, unless the vessel was going at a great speed, would probably be sufficient to arrest her. They therefore proposed to put in duplicate gates in each of these locks, and not to put in the special gate that I have just referred to, which has never been designed. So that they have introduced, as you can see here, in this triple flight, and also at their other locks, a second set of gates.

If you will scale off the distance from this map, you will find that they have got the 900 feet in the clear between the outer gates, but only 790 feet in the clear between the inner gates.

Senator KITTREDGE. You mean by "the outer gates" the lower gate at the lower lock and the upper gate at the upper lock?

Mr. PARSONS. They double the gates all the way through, at each lock.

Senator KITTREDGE. And have they accounted for that doubling?

Mr. PARSONS. They have accounted for it simply in that way—by subtracting it from the effective length of the lock. In other words, if the double gates are to be used, then the lock has an effective length of something less than 800 feet. If the double gates are not to be used, then they get an effective length of lock of 900 feet, as they have planned.

Senator KITTREDGE. What is the length of the largest ship now being constructed?

Mr. PARSONS. Seven hundred and eighty-eight feet, I think—one of the Cunarders.

Senator KITTREDGE. Could that ship go through this lock?

Mr. PARSONS. It could not, unless they left the safety gates off. Then, of course, the criticism comes right back to where the majority members of the board opposed the lock scheme—that there is no safety device against a vessel plunging through.

Senator KITTREDGE. Did they agree with you that the safety gate should be put in the construction?

Mr. PARSONS. Apparently; they put it in. You see, Senator, the minority report was written after the majority report was written, so that the majority members had no chance to in any way reply to the minority report. The majority of the board prepared its report, then that was submitted to the dissenting members and the minority report was written. The members signing the majority report simply saw it at the last session, when the board met to adjourn sine die.

Senator KITTREDGE. Would the safety gates that you have spoken of prevent the ship plunging down through the lock as you have stated?

Mr. PARSONS. I think they probably would. I think that if two gates were there, under ordinary conditions, with a vessel approaching at, say, 5 or 6 miles an hour, probably the second gates would be sufficient to hold her.

Senator KITTREDGE. You say "probably;" are you able to say that they certainly would?

Mr. PARSONS. If you take a large ship, moving even at a slow rate, 5 or 6 miles an hour, her momentum is so great that it is very difficult to say what she would not do.

Some few years ago when one of the French liners, I think, was clearing from New York, the pilot made a mistake and thought she was going to clear the end of a pier. The ship was moving at a very slow speed, but she cut halfway through one of those big piers before she was stopped. So that in the case of a big steamer having, besides her own weight, 8,000 or 10,000 or 15,000 tons of cargo, what she would do under a given speed would be very hard to tell. Of course when she is stopped it would be a different thing.

Senator KITTREDGE. Then, in your judgment, the danger of crushing down through those locks is always present?

Mr. PARSONS. I do not think there is any doubt about it. That is my criticism of a lock canal.

Senator KITTREDGE. You mean even with the safety gates added?

Mr. PARSONS. Even with the safety gates added; and, of course, you must always remember in that particular case that with a very large steamer, where the safety gates could not be closed—they would have to be open, because otherwise you could not get her in—you would have no safety device as against the most dangerous type of vessel. The larger the vessel the more difficult she is to handle, and the more difficult she is to stop. Her momentum is greater by reason of her greater weight.

Senator KITTREDGE. Then, as I understand you, notwithstanding the statement in the minority report of the usable dimensions of this dock as 900 feet by 95 feet, in the plan presented to us the usable dimensions are in fact 790 feet as to length?

Mr. PARSONS. That is a fact.

Senator KITTREDGE. By what width?

Mr. PARSONS. Ninety-five feet.

Senator KITTREDGE. Is it not possible to lengthen the entire lock structure so as to have a usable length of 900 feet?

Mr. PARSONS. It is not possible to do that and still keep the three locks in flight.

Senator KITTREDGE. Why is that?

Mr. PARSONS. The topography of the ground, falling off at both

ends, that you could not get a longer structure in there. In fact, Mr. Bates himself pointed out to you in his testimony that even with the locks as designed, the guard wall in the middle would have no foundations on rock. I do not think that Mr. Bates's criticism in that regard has any very large amount of weight, because a wall of that description need not be founded on rock. It is simply for vessels to be guided against, and a pile structure would probably answer quite as well as a structure founded on rock. But the principle involved is true, that if you lengthen these locks the end gates are not going to have a suitable foundation.

Senator KITTREDGE. I wish you would explain that point in detail. I do not quite understand why it can not be lengthened.

Mr. PARSONS. The majority members of the board, and, in fact, all the board except two members, voted at the outset that all locks should have a usable length of 1,000 feet and a width of 100 feet. That question was decided by a vote of, I believe, something like eleven to two; and it was in order to allow not only for the vessels now building but for such increase in size of vessels as could be foreseen. It is quite possible that we shall have, in the course of a few years, vessels 900 feet in length; and a vessel 900 feet in length will need a 1,000-foot lock. So that the board decided, by a vote of eleven to two, without regard to the type of canal, that the locks should have a usable length of 1,000 feet and a width of 100 feet.

When the minority came to prepare their preferred plan, which was to keep the three locks in flight at Gatun in order to diminish the expense of the canal, it was found that three 1,000-foot locks could not be constructed at that site. There is a divide there, a ridge, with suitable material for foundations—rock or a very hard clay, amounting almost to a rock, and at such reasonable depth as to be reached by the locks. But when you came to make the locks of a thousand feet each, with the space between the locks for the gates and the clearances between the locks, the ends of that structure would overhang the sides of this ridge so that the ends would not have a proper foundation. The ends would include, of course, the end-gates at both ends, where it is most important that there should be a satisfactory foundation.

The minority, therefore, decided not to use 1,000-foot locks. In other words, three members of the minority reversed themselves in their original decision of a thousand feet, and dropped back to a 900-foot lock, so as to get in three locks of 900 feet each in this situation.

Then, when an objection was made to the danger of locks in flight, they still further reduced it, as Mr. Bates has pointed out, by introducing the safety gates, the second set of gates, and by putting them inside of the 900-foot length.

Senator KITTREDGE. And thereby reducing the usable length dimension to less than 800 feet?

Mr. PARSONS. To something less than 800 feet.

Senator MORGAN. Mr. Parsons, while you are on the subject of locks, I would like to make an inquiry: Do all of the great canals, the Suez and the Manchester and Kiel, and so on, and the Soo Canal, use the folding gates yet?

Mr. PARSONS. The Suez Canal has no locks.

Senator MORGAN. It has a sea-gate, has it not?

Mr. PARSONS. I think not. They use no gates whatever, no locks at all. At the other canals, the Manchester and the Kiel, they have the ordinary type of folding gates.

Senator MORGAN. They have folding gates, also, at the Soo?

Mr. PARSONS. They have folding gates also at the Soo.

Senator MORGAN. Is there any project on foot among engineers to get a better gate than that?

Mr. PARSONS. Gates have been projected and designed, I believe, for the Soo Canal of different types; but up to date no design has been found to be satisfactory to take the place of the original type of folding gate.

Senator MORGAN. Have you ever examined the rolling gate that was invented by Lieutenant Peary?

Mr. PARSONS. Not in detail; no.

Senator MORGAN. Did you know what his project was—what the outline of it was?

Mr. PARSONS. Yes; I know there have been a number of those rolling gates devised, gates of all sorts of types; but they never have commended themselves sufficiently to the parties in charge of big lock gates to have them adopted.

Senator MORGAN. Of course the gates always open back into the lock?

Mr. PARSONS. That depends on which gate it is. The upper gates, of course, would open away from the lock.

Senator MORGAN. But if they are locks in tandem?

Mr. PARSONS. If they are locks in tandem, then, of course, they would be inside.

Senator MORGAN. In a lock of the width that you describe how many feet wide is it?

Mr. PARSONS. The minority lock was 95 feet wide. The lock preferred by 11 out of the 13 members of the board was 100 feet wide.

Senator MORGAN. That would be 50 feet for each gate. You have to make room for those gates to open and close?

Mr. PARSONS. Certainly.

Senator MORGAN. And you have to add that to the length of the lock?

Mr. PARSONS. You have to add that to the length of the lock.

Senator MORGAN. Is that provided for in this design?

Mr. PARSONS. Yes. When we speak of 900 feet or of 1,000 feet, we always refer to a 900-foot or 1,000-foot (as the case might be) usable length.

Senator MORGAN. That is what is meant by "usable length?"

Mr. PARSONS. That is what is meant by "usable length." The space taken up by the gate, therefore, is not to be deducted. In the case of the safety gates, as I have just explained, in the point raised by Mr. Bates—

Senator MORGAN. I did not undersand exactly what was meant by "usable length," and I wanted to find it out.

Senator DRYDEN. What would happen to a vessel going through there that might smash down those locks, Mr. Parsons?

Mr. PARSONS. In going through three locks?

Senator DRYDEN. Yes; if it smashed the locks down when it was going through, what would be likely to be the fate of that vessel?

Mr. PARSONS. I think that probably the insurance companies would own it.

Senator DEYDEN. You think that the lives and the freight would all be lost?

Mr. PARSONS. I do not think that a vessel would have much value after making a jump of 85 feet in three steps.

Senator MORGAN. The Government would have the expense of the burial, would it?

Mr. PARSONS. The wreck itself might have to be removed somewhere; but I think pretty much everything that was movable would be somewhere out in the Caribbean Sea, Senator.

Senator KITTREDGE. Going back for just a minute to the locks: Suppose that they extend this lock structure to secure a usable dimension of 900 feet in length, the ends of each lock would extend into space or into the air. Is that right?

Mr. PARSONS. They would. You would have to build up to them.

Senator KITTREDGE. Does that expression accurately convey the situation to the mind of a layman?

Mr. PARSONS. I should imagine that it would, Senator.

Senator KITTREDGE. You said something a moment ago about building up in order to make the entrance to these locks. Please explain that.

Mr. PARSONS. You can imagine the cross section of a hill with the flanks of the hill and a curved top. Now, you can make an excavation of a certain length that will be wholly within the hill, or you can also imagine an excavation of a certain length where the ends of the excavation (I am now going to make a "bull") will be outside of the hill, considering the excavation as a trough, for instance. And when you come to lengthen these locks, as Mr. Bates has pointed out, that is exactly the condition that you would strike here at Gatun; in other words, that the hill is not sufficiently long to take in the locks and the lock structure.

Senator KITTREDGE. In accordance with the plan proposed by the minority?

Mr. PARSONS. In accordance with the plan proposed by the minority.

Now, take the locks they themselves have laid out, and you can see here in a moment the great length required. From end to end of their walls is a distance of 5,500 feet. In other words, there is a masonry structure there a mile long, as they plan it out.

Senator KITTREDGE. Is it necessary to have that length of structure?

Mr. PARSONS. Yes.

Senator KITTREDGE. Why?

Mr. PARSONS. The locks themselves, exclusive of the approach walls, cover a distance of 3,000 feet. Then you have the approach guide walls in addition to that, which are planned to be of masonry; so that, according to that plan, you have a structure there over a mile long. Now, then, if the locks are to be lengthened from 790 to 1,000 feet of usable length, you see you are going to add over 600 feet, again, to that. In other words, in that case the total masonry structure would be considerably over 6,000 feet, nearly a mile and a quarter, in length.

Senator KITTREDGE. Where is the entrance of the lock structure with reference to the depot at Gatun—north or south of that point?

Mr. PARSONS. It is almost abreast of it.

Senator KITTREDGE. And then extending to the north?

Mr. PARSONS. And then extending to the north. It is almost abreast of it, and just to the east of it.

Senator KITTREDGE. You spoke a moment ago of building up to this lock if they extended it so that they could have a usable dimension exceeding 790 feet?

Mr. PARSONS. Yes; because, if you will consider the locks themselves as a trough, and then placed in the hill, the ends of that trough would overhang the side of the hill. Therefore you would have to build down from that trough to the rock below in order to get a foundation to support the ends of that trough.

The CHAIRMAN. There is no reason why that can not be done, Mr. Parsons, is there?

Mr. PARSONS. The rock is very far down. It simply adds tremendously to the expense; that is all.

Senator DRYDEN. Can you tell about what would be the height of this support or masonry work, I suppose it would be, required to reach the ends of the locks?

Mr. PARSONS. I think I could this afternoon. I could not give it to you offhand, because I have not worked it out; but I was merely explaining the question that Senator Kittredge asked, in explanation of Mr. Bates's criticism that the locks only had a length of 790 feet and not of 900 feet. I was explaining that that was a fact, and why it came about.

Senator DRYDEN. It becomes a matter of expense, then?

The CHAIRMAN. I could not understand that at all yesterday, but it is perfectly plain now, since I see what Mr. Parsons says.

Senator DRYDEN. It becomes, then, a matter of expense; and, as I understand, Mr. Parsons, these supports could be built?

Mr. PARSONS. Oh, yes.

Senator DRYDEN. But it is a question of expense?

Mr. PARSONS. It is a question of expense.

Senator DRYDEN. I assume that you, not having the distance in mind, have not made any calculation as to what that expense would be?

Mr. PARSONS. I have not. Of course it is not merely a question of building up a block of masonry to carry the gates; but you have to have enough masonry to take up the thrust of those gates. You see the gates themselves act like an arch with the pressure of the water against them, and they have to have abutments; so that it is like carrying an arch away up in the air. You have to build abutments to support that arch, and that is the reason why you have to have such good foundations under your lock gates. If you have no rock except at great depth, and you have to build up to this gate, you have to build up a very heavy abutment in order to support the thrust of the arch of the gates themselves.

Senator DRYDEN. Could you give us an approximate idea as to the cost of building such supports, whether it would be one million dollars or five million dollars, or anything of that kind?

Mr. PARSONS. Oh, offhand, I could not, but it would run into a good many millions of dollars. I think it would be sufficient in itself to condemn the idea of locks in flight at Gatun entirely apart from the question of safety. I think that the expense alone, if those locks were to be made a thousand feet long (as they unquestionably should

be, and as 11 out of the 13 members of the board decided that they should be before any question of type of canal was raised at all), would be sufficient to condemn that plan.

Senator DRYDEN. In short, you consider that the flight of locks at this point would be impracticable as to dimensions which would accommodate the largest ships now in process of construction?

Mr. PARSONS. I think so.

Senator MORGAN. Let me ask you there, please, this question: These lock gates describe an arch against which the pressure comes laterally?

Mr. PARSONS. Certainly.

Senator MORGAN. They have to bear the entire burden of the water that is in the lock, as I understand it, with the superadded burden of the weight of the ship that is in the lock?

Mr. PARSONS. As far as the superadded weight of the burden of the ship is concerned, of course she displaces that same amount of water.

Senator MORGAN. Yes.

Mr. PARSONS. So that it would be the same in either case.

Senator MORGAN. But still it is all confined in the lock chamber?

Mr. PARSONS. It is all confined in the lock.

Senator MORGAN. Now, is it not of the first importance that those gates and the abutments to them should be as strong as or stronger than any other part of that lock?

Mr. PARSONS. That is the weakest part of the lock; and the abutments to those gates must be sufficiently strong to protect those gates from yielding.

Senator MORGAN. And the danger comes, in a lock canal, more from the gates than from the walls on either side?

Mr. PARSONS. Oh, yes.

Senator MORGAN. Or the floor?

Mr. PARSONS. Or the floor.

Senator MORGAN. That is all.

Senator DRYDEN. I would like to ask your opinion as to the relative weaknesses of these two types of canal against the effects of an earthquake. I would be glad if you would point out the weak points of the lock type of canal and compare it with the same matter with regard to the sea-level canal.

Mr. PARSONS. So far as the main structures are concerned, I do not think that there is very much difference. I do not think that there is much to fear from an earthquake for either type of canal, so far as the main structures are concerned.

The lock gates must be nicely adjusted in order to work properly, and I think it is conceivable that an earthquake which would not produce any very great structural damage might be sufficient to distort the adjustment of the gates and their foundations, so that the gates themselves would not work. Of course that is a damage which could be repaired, but it would put the locks out of service while it was being repaired, and that, I think, is the major danger that would be feared from an earthquake for either type of canal.

Senator DRYDEN. I will ask you the same question as applied to the attack of an enemy, say, in case of war.

Mr. PARSONS. In the case of war the locks, of course, are the vulnerable part. One man can carry enough high explosives in his clothes to put a lock out of service, if not to destroy the canal. I am speaking now of a lock canal. Of course in the case of the sea-level

canal the tidal lock could be destroyed in a similar manner; but in that case the canal itself would not be destroyed. The canal would still remain usable even with the tidal lock destroyed, because at least for one-half the time that tidal lock would stand open. Then, the rest of the time, during the period of the month when we get what is known as the spring tides, the extra high tides, there would be two times a day when the level of the water inside and outside would be the same, and a great portion of the day vessels could still enter and leave the canal. So that in the event of the tidal lock being destroyed by high explosive the canal itself would not be destroyed; but in the case of a lock canal the destruction of a lock or locks would of course destroy the canal.

One man can carry enough dynamite in there to destroy a lock. If you say that the locks would be so guarded that strangers could not approach them, it is easily conceivable that an enemy could take a small steamer and load her with dynamite or some other high explosive—a vessel clearing with the ordinary papers, and apparently loaded with bananas and making the voyage in the ordinary commercial way. That vessel would get in the top one of these locks, and while in the process of being locked through the crew would simply jump ashore, and possibly inform the lockmen that that vessel was loaded with nitroglycerine and was going to explode in half a minute. There would be nothing in the world to stop it, you know; and you would always find, in the case of a war, men who would be perfectly willing to take that risk.

Senator DRYDEN. And the destruction of these locks could be made as complete as in the case of a vessel smashing them down, which you have heretofore described?

Mr. PARSONS. Quite.

Senator DRYDEN. And even if the work was uninterrupted, and in time of peace, it would take from three to five years to restore those locks, according to your view?

Mr. PARSONS. Probably.

Senator MORGAN. The plan of the minority, as I understand it, is for a flight of locks at Gatun?

Mr. PARSONS. For a flight of locks at Gatun.

Senator MORGAN. Two locks, one following the other?

Mr. PARSONS. Three.

Senator MORGAN. Does the immediate connection of the three locks together increase the danger to ships navigating that canal, one above the other? Is their immediate connection together? I suppose they are all connected together.

Mr. PARSONS. They are all connected together, so that a vessel goes from one to the other in a succession of steps.

Senator MORGAN. Through the gates?

Mr. PARSONS. Through the gates.

Senator MORGAN. Does the fact of putting three locks together in flight increase the danger of navigation through the locks?

Mr. PARSONS. Yes; because a vessel plunging through the three locks would undoubtedly make a far worse accident than a vessel going through a single lock.

Senator MORGAN. Is there any greater danger of meeting an accident?

Mr. PARSONS. A greater danger of meeting an accident in going through three locks in flight as against three separate locks?

Senator MORGAN. Yes.

Mr. PARSONS. I do not know that there would be. The accident itself would be greater if it occurred.

Senator MORGAN. Yes; the accident would be greater, but you do not think that the exposure to danger would be any greater?

Mr. PARSONS. I do not think so. I do not think a flight of three locks would present any greater danger than three single detached locks. The vessel has to make three movements. The danger, of course, arises when you have your vessel in motion.

Senator MORGAN. That is exactly what I have had in mind. The vessel has to make three movements?

Mr. PARSONS. The vessel has to make three movements.

Senator MORGAN. Each of these movements gets up an impetus, and with such a vast mass of metal, or such a vast ship floating, that is very hard to check, is it not?

Mr. PARSONS. It is.

Senator MORGAN. There has to be very careful work done in checking it, to prevent it from going through the gates?

Mr. PARSONS. Unquestionably.

Senator MORGAN. It is a difficult operation?

Mr. PARSONS. Very.

Senator MORGAN. And a dangerous one?

Mr. PARSONS. Very.

Senator MORGAN. If that is repeated three times in succession, the danger would be, it seems to me, increased in some proportion at least.

Mr. PARSONS. I do not know that it makes any difference whether you make those three movements in close succession or whether you make them at longer intervals. The movements are exactly the same.

Senator MORGAN. In the case of a flight of three locks, an accident to either gate in that flight would involve the whole length of the system, would it not?

Mr. PARSONS. No; not necessarily. Suppose a vessel had passed the upper lock in safety, and was in the middle lock, and then something went wrong, and she carried away the gates—the gates of the upper lock would hold back the water in the upper level. You would simply then destroy the vessel and the lower two locks, and probably not enough water would go down to destroy the lower reach of the canal. That would not make a catastrophe; it would make a bad accident so far as that vessel was concerned and so far as the lower gates were concerned.

Senator MORGAN. Suppose the accident should occur as the vessel was entering the first lock of the three?

Mr. PARSONS. She would probably carry all three away.

Senator MORGAN. She would probably carry all three away?

Mr. PARSONS. Yes, sir.

Senator MORGAN. The damage, then, to the canal would be probably threefold in a case of that sort?

Mr. PARSONS. That is it, exactly.

Senator MORGAN. Yes.

Mr. PARSONS. And that is the reason why the majority of the board in formulating a plan for a lock canal was insistent that the locks themselves should be separated, so as to diminish the accident.

Senator MORGAN. Did they lay emphasis upon that proposition, that locks separate from each other would be safer—

Mr. PARSONS. Oh, yes.

Senator MORGAN (continuing). Than when connected in a flight?

Mr. PARSONS. Oh, yes; yes.

Senator MORGAN. That is what I wanted to get at.

Mr. PARSONS. The majority of the board was quite insistent on that point. The minority members of the board preferred putting them in flight because it is cheaper construction.

Senator MORGAN. Yes.

Mr. PARSONS. In other words, they were avowedly governed, as they stated, by that consideration.

Senator MORGAN. They preferred it on account of the less cost?

Mr. PARSONS. On account of the less cost.

Senator MORGAN. That was the whole affair?

Mr. PARSONS. That was the whole affair. They disagreed with us, I think, in our estimate of the danger involved. I want to say that—that the minority did not share our views in regard to the total amount of danger, or, otherwise, those gentlemen would never in the world have prepared the plans they did. They did not, and I presume do not, agree with us in regard to the probable danger. They think a vessel can be controlled, and that the accident of a vessel plunging through a flight of three locks will not occur.

Senator KNOX. What has been the experience at other locks in other canals?

Mr. PARSONS. In the Manchester Canal the accident has happened three times, as I described a few minutes ago.

Senator KNOX. Yes; I was not here.

Mr. PARSONS. When vessels have actually gone through the locks. In that case the locks were separate and the gates were closed by the men on shore. Seeing that the vessel was going through—that control had been lost of the vessel—they succeeded in partially closing the gates, and the rush of the water following the vessel brought the gates to with a great bang. The gates were wrecked, but not sufficiently wrecked as to be entirely carried away, so that the water in the upper level, in each one of the three cases, was, fortunately, restrained; otherwise, of course, there would have been a terrific disaster.

Senator MORGAN. The vessel was saved by the alacrity of the men in closing the gates?

Mr. PARSONS. The canal was saved; the vessel went through. The canal was saved by the alacrity of the men in getting the gates started, and they were half closed, and then, of course, the terrific rush of water carried the gates themselves to.

Senator MORGAN. Yes.

Mr. PARSONS. Each one of those locks, I think, was out of service for something like a month before new gates could be put in place. The locks were in duplicate, however, so that the canal was able to maintain traffic in a partially crippled condition.

Senator DRYDEN. What have you to say about the waste of space and water in the use of these locks for small boats?

Mr. PARSONS. That, of course, is very, very great. That is another objection. It is a minor one, but it is another objection to locks in flight. If you have a single lock you can then put in intermediate gates, dividing your 1,000 feet into lengths of, say, 600 and 400 feet, or whatever lengths you might prefer, so that short vessels in passing one of the locks need not draw off a full lockful of water. But where you come to have the locks in flight that arrangement is not possible, and you have to draw off a full lockful of water every time, so that the waste of water in the case of locks in flight is very much greater than it would be in the case of separate locks.

Senator DRYDEN. That goes to the point of the possible congestion that might occur in a fleet of vessels getting through, getting along the canal; but as to the waste of water, how serious a matter is that? How important is that?

Mr. PARSONS. I do not attach very much importance to it; and for that reason I have not raised it. It is merely an objection.

The lakes that have been proposed by the minority, as you can see by looking at the map there, are very great; and those lakes will store enough water through the dry season to permit the locking through of, I think, any tonnage that can now be foreseen. Should, however, the occasion demand, and the tonnage be increased, an additional dam could be put in on the upper Chagres at Alhajuela, and possibly at some of the other tributaries, so that practically the whole of the rainfall of the Chagres Valley could be stored; and in that case enough water could be obtained to lock through, I think, any imaginable amount of tonnage.

Senator DRYDEN. But in regard to the congestion. If the demand upon this canal should get to be very, very great and a fleet of vessels was waiting to get through, and one of these long locks had to be given up entirely to a small boat, that would be quite a serious matter, would it not?

Mr. PARSONS. It would be quite a serious matter.

Senator MORGAN. In the delay which would occur in these vessels getting through?

Mr. PARSONS. It would be quite a serious matter unless two or three of those small boats should come together, then they could be locked through simultaneously.

Senator DRYDEN. Would that be safe and practicable?

Mr. PARSONS. Oh, they do that right along at the Soo. But that means that vessels have got to arrive simultaneously, or substantially simultaneously, in order to get that done. If you are going to hold one vessel until the next boat arrives, of course you are going to delay the first vessel.

Senator HOPKINS. What do you estimate is the time necessary to lock a vessel through a three-lock flight?

Mr. PARSONS. That was set forth in the report of the Isthmian Canal Commission--the so-called Walker Commission.

Senator HOPKINS. I am asking you what your estimate is--in the objections you make to it.

Mr. PARSONS. I was going to give you those figures. The figures that they gave in that report I concur in.

In the report of the Board of Consulting Engineers there is no detailed calculation showing the time required to pass a vessel through

the locks. You will find in that report a paper written by Mr. Noble and Mr. Ripley on the capacity of the canal for traffic, in which there is a statement —

Senator KITTREDGE. You refer to the minority report?

Mr. PARSONS. No; I am referring to a paper which appears in the appendix to the report (it is really simply a contribution), in which they show a calculation as to the traffic that a lock canal could carry. They show there, in a flight of three locks, a computation that if everything worked exactly right vessels could pass at intervals of fifty minutes through a three-flight lock. That is, by the time, of course, the vessel passed the first lock, when she got down into the second lock, but while she was going through the intermediate lock the upper lock would be filled, and the next succeeding vessel would enter the upper lock while the first vessel was still passing through the lower lock; and they make the calculation that vessels could follow each other at intervals of about fifty minutes. That, of course, is based wholly on theoretical considerations. If you refer to that paper you will see that it worked out into seconds, and it means that everything has to work exactly right.

Now, in practice, it is found, in the case of lock canals, that you have to allow about 50 per cent in addition to the theoretical computation to cover the unavoidable delays. The instant the gates are opened the vessel is not quite ready to move; the captain waits, naturally, until the gates are opened, and until he knows they are open. Then he has to give his orders to cast off his lines, and that all takes time; and there is the inevitable delay that you can not possibly avoid in the handling of a large ship.

Senator HOPKINS. Are you familiar with the manner in which they lock vessels through at the Soo, and the time that it takes there?

Mr. PARSONS. Yes. Mr. Ripley was superintendent of the Soo Canal, so that his computation is based upon his own experience in the filling and the opening of locks, but they make no pretense that that is a practical calculation. It is merely a theoretical calculation of the minimum time required.

Senator HOPKINS. You have no personal experience, have you, on this question, either at the Soo or at any other place?

Mr. PARSONS. Except as I have —

Senator HOPKINS. Except as you have gathered statistics from others?

Mr. PARSONS. Except as I have sat with a watch and timed vessels going through locks.

Senator HOPKINS. That is what I wanted to know—whether you have done that.

Mr. PARSONS. Yes, sir.

Senator HOPKINS. Where was that—at the Soo?

Mr. PARSONS. I have timed them on the Manchester Canal, and I have timed them on the Kiel Canal—large steamers.

Senator HOPKINS. What is the length of time at those two places?

Mr. PARSONS. I can not tell you offhand, because I have not my notebook here with me. Of course, in both those cases, the locks have very much lower lifts than there would be here.

Senator HOPKINS. What is the depth of the lock at Manchester?

Mr. PARSONS. Six hundred feet.

Senator HOPKINS. How many locks are there?

Mr. PARSONS. There are four locks and a tidal lock—five altogether.

Senator KITTREDGE. In flight?

Mr. PARSONS. No; they are separate.

Senator HOPKINS. How is it at the Soo?

Mr. PARSONS. The Soo has one lock at one place, but I think there are some four locks, and the Government is now building a fifth to accommodate the traffic.

Senator HOPKINS. Are they in flight, or separate?

Mr. PARSONS. No; that is a single lock.

Senator HOPKINS. And what are the lengths of those locks?

Mr. PARSONS. They vary a great deal. Originally there were two tandem locks, each 350 feet long by 70 feet wide, having a lift of 10 feet each. Then the Weitzel lock, 550 feet long, was built, between 1870 and 1881. Then the original tandem locks were replaced, between 1887 and 1896, by the Poe lock, 800 feet long and 100 feet wide.

Senator KITTREDGE. And of what lift?

Mr. PARSONS. A lift of 20 feet. That makes two locks. Then there is the Canadian lock, which is 900 feet long and 60 feet wide; and now, I believe, the Government is projecting a new lock.

Senator KITTREDGE. In that connection, Mr. Parsons, do you remember the usable dimensions of the lock at Panama proposed by the French company in 1896 or 1897?

Mr. PARSONS. Seven hundred and forty feet, I think, if I recollect rightly.

Senator KITTREDGE. Do you remember the usable length of lock proposed by the Walker Commission, appointed in 1899 and reporting in 1901?

Mr. PARSONS. Have you a copy of that report here? I would like to refer to it.

Senator MORGAN. That is obsolete.

The CHAIRMAN. I do not think we have a copy handy to-day, Mr. Parsons.

Mr. PARSONS. It is from 740 to 800 feet—somewhere in that neighborhood.

Senator KITTREDGE. Do you refer to the report of the Walker Commission?

Mr. PARSONS. I refer to the report of the Walker Commission.

Senator KITTREDGE. It was 800 feet, was it not?

Mr. PARSONS. I think it was about 800 feet—somewhere between the French figure and 800 feet.

Senator KITTREDGE. And you were showing this morning that the locks proposed by the minority on paper proposed to give a usable dimension of 900 feet, but in fact they are less than 800?

Mr. PARSONS. In fact, they are less than 800.

Senator KITTREDGE. And the largest ship now building on the stocks is of what length.

Mr. PARSONS. Seven hundred and eighty-eight feet, I think.

Senator KITTREDGE. You can supply those exact figures later, if you will, Mr. Parsons.

Mr. PARSONS. I will get them during recess.

Senator KITTREDGE. As to the locks projected by the French, and then by the Walker Commission?

Mr. PARSONS. I will get that information during recess.

Senator MORGAN. You were on the commission when that report was made, were you not?

Mr. PARSONS. No, sir.

Senator MORGAN. You were not?

Mr. PARSONS. I was not on the so-called Walker Commission.

Senator MORGAN. No; I remember now.

Senator HOPKINS. Are there any conditions that exist there at Gatun that would interfere with their having a lock 900 or 1,000 feet long?

Mr. PARSONS. Yes. The topography is such that you could not get in the three locks.

Senator MORGAN. Why?

Mr. PARSONS. The hill is not long enough.

Senator MORGAN. It gives out?

Mr. PARSONS. The hill gives out.

Senator HOPKINS. Could they not have two locks? Could they not meet the question there by a two-lock system instead of three?

Mr. PARSONS. Certainly.

Senator HOPKINS. And then they could have a 1,000-foot lock there, could they not?

Mr. PARSONS. Certainly; but that is not the plan that the minority propose.

Senator HOPKINS. I am not speaking of whether it is their plan or not; but they could, at that point, have a two-lock system of 1,000 feet each?

Mr. PARSONS. I think the best thing to do—

Senator HOPKINS. I am not asking you what is the best thing to do. They could have that, could they not?

Mr. PARSONS. Certainly.

Senator MORGAN. What would be the lift of those two locks?

Mr. PARSONS. If you are going to come up to the 85-foot level, they would be 42½ feet apiece, Senator.

Senator MORGAN. That is a very high lift, is it not?

Mr. PARSONS. That is a very high lift—a lift that has never been built.

Senator MORGAN. A dangerously high lift?

Mr. PARSONS. I think there is no question about it.

Senator MORGAN. Now, I want to ask you just a few questions. That dam at Gatun is 85 feet high?

Mr. PARSONS. Eighty-five feet high.

Senator MORGAN. It is meant to carry a head of water 85 feet deep?

Mr. PARSONS. Yes. When you speak of the height of the dam, the dam itself is to be some 50 feet higher than that, as projected; but it is to carry 85 feet of water.

Senator MORGAN. Yes; 85 feet of water. That 85 feet of water is expected to reach across to Miraflores or to Pedro Miguel somewhere?

Mr. PARSONS. Yes.

Senator MORGAN. Clear across the cut?

Mr. PARSONS. Clear across until you get to the Pacific slope.

Senator MORGAN. It is also expected to make dead water on the right bank of the Chagres River and a very considerable distance up the Gatun River and the next river to it, the Gatuncilla? Are there two rivers there, one called the Little and the other the Big Gatun?

Mr. PARSONS. There are really two Gatuncilla Rivers, and we have

been inclined to call the lower Gatuncilla, the one at Gatun, the Gatun River. There is another Gatuncilla that is tributary to the upper Chagres. They are both called the Little Gatun.

Senator MORGAN. Keeping up the right bank of the Chagres River, taking in all the affluents until you get up to Gamboa, this lake seems to go up above Alhajuela?

Mr. PARSONS. Almost up to Alhajuela.

Senator MORGAN. Almost up to Alhajuela?

Mr. PARSONS. Yes, sir.

Senator MORGAN. Alhajuela, then, on this map, would be outside of the map itself?

Mr. PARSONS. No, sir; here is Alhajuela [indicating].

Senator MORGAN. Oh, yes. Then it goes away above it?

Mr. PARSONS. The lake itself comes up to a point a few miles south of Alhajuela. It does not quite get to Alhajuela.

Senator MORGAN. From Alhajuela on up to the top of this map that is before us have topographical surveys been made of sufficient accuracy to determine what would be the body of water in that upper region of the Chagres?

Mr. PARSONS. Substantially; yes.

Senator MORGAN. Then, coming on to the left bank of the Chagres River, there is a body of dead water that runs down there. That represents what river, the Indio?

Mr. PARSONS. The valley of the Trinidad.

Senator MORGAN. The Trinidad?

Mr. PARSONS. Yes; that is the Trinidad. The Indio flows directly into the sea. That is another valley.

Senator MORGAN. Now, next upon the left bank comes in another river. What is that, the Indio?

Mr. PARSONS. These rivers in here [indicating]?

Senator MORGAN. Yes.

Mr. PARSONS. This is the Gigante.

Senator MORGAN. Yes, the Gigante; and those are the principal streams that enter on the left bank of the Chagres River until you get up to Bohio?

Mr. PARSONS. Yes.

Senator MORGAN. And then the Obispo comes in on the left bank?

Mr. PARSONS. And then the Obispo comes in on the left bank.

Senator MORGAN. What is that other main stream just above the Obispo that comes in on the left bank farther up the Chagres—that long one, above where your pencil is?

Mr. PARSONS. That one [indicating]?

Senator MORGAN. No; still farther up the map—that middle one.

Mr. PARSONS. Do you mean that one [indicating]?

Senator MORGAN. Yes.

Mr. PARSONS. That is not a river at all. That is the old highway from Las Cruces to Panama.

Senator MORGAN. Oh, yes; I was mislead by that. Now, all of that weight of water practically bears upon the Gatun dam? I do not mean as weight, but I mean as pressure.

Mr. PARSONS. Yes.

Senator MORGAN. It has to be strong enough to hold all of that water at an 85-foot level (not above its base, but at the surface level of 85 feet) over all this great area that is mentioned here?

Mr. PARSONS. As a matter of fact, Senator, the pressure on that dam would be just the same if that lake extended back but a few feet. The extent of the lake does not increase the pressure on the dam.

Senator MORGAN. That is the point I was trying to get at. Can you account for that?

Mr. PARSONS. The pressure is due to the height of water, and not to its width. This water back here is not exerting a pressure against that dam. That is being carried on the ground beneath it. It is the water next against the dam which makes the lateral pressure. The lateral pressure is due, in other words, to the height, and to the height only.

Senator MORGAN. As an engineering rule, or as a rule of hydraulics, how far from the Gatun dam would that pressure extend? Take it in feet or yards.

Mr. PARSONS. Theoretically, no distance at all.

Senator MORGAN. None whatever?

Mr. PARSONS. None whatever. It is simply a question of the height of the water against your dam, so that the extent of the lake behind it, back, has no effect upon the dam itself.

Senator MORGAN. And if the height of water—that means the depth of it—was half of 85 feet, the pressure would be just half?

Mr. PARSONS. Just half.

Senator MORGAN. And so on down—graded on down in that way?

Mr. PARSONS. Yes, sir.

Senator MORGAN. It depends entirely upon the perpendicular?

Mr. PARSONS. It depends entirely upon the perpendicular height and not upon the lateral distance of the surface of the water.

Senator MORGAN. Then every foot that you raise the water above the normal level adds that much pressure to the dam?

Mr. PARSONS. It adds that much pressure to the dam.

Senator MORGAN. And that is the pressure that the dam has to withstand?

Mr. PARSONS. That is the pressure that the dam has to withstand.

Senator HOPKINS. What is that pressure per foot?

Mr. PARSONS. One hundred feet of water weigh about 43½ pounds. So you see that it is a little less than half a pound per foot.

Senator MORGAN. I have no further questions to ask with respect to that matter. It looks to me like a very poor substitute for Lake Nicaragua, however, which was 102 miles long, 45 miles across, and 40 feet deep, with a lake above it 25 miles long and 22 miles wide and about 50 feet deep. I think nature or the Almighty has done more for us there than the engineers will ever be able to do at Panama.

Senator HOPKINS. Mr. Parsons, you spoke about some accident occurring in the Manchester locks and at one other place. The conditions were abnormal, were they not, at the time of the accident that you spoke of?

Mr. PARSONS. No, sir; no, sir. They were just the ordinary conditions of traffic.

Senator HOPKINS. How did the accident occur, then, if the conditions were normal?

Mr. PARSONS. One case that I described, to show how an accident may occur, was when the wire parted between the—

Senator KNOX. He has been all over that.

Senator HOPKINS. Oh, I withdraw the question, then. You have been all over this proposition, have you?

Mr. PARSONS. Yes, sir.

Senator HOPKINS. Then I will not repeat it. Of course I came in later; but I will read your evidence.

Senator DRYDEN. Mr. Parsons, the statement has been made, I think, that a lock canal can be completed in a little over half the time that a sea-level canal can, and at something over \$100,000,000 less in cost. Have you any figures upon that matter?

Mr. PARSONS. I think that the time for the construction of the sea-level canal has been rather overstated in that estimate. The advocates of the sea-level canal felt that the canal could be constructed in from ten to eleven years.

In the hope that we could get a unanimous vote upon that period of time we agreed to make it from twelve to thirteen years; and that resolution stood, which I considered, in my judgment, was a year or more too much. It would undoubtedly take a longer time to construct than the lock canal, but I do not think anything like the extent of two to one. In the construction of these huge locks, with all their complicated machinery, which would have to be built up step by step, I think the chances for delay are quite as great as the chances for delay in the making of the larger excavation.

(At this point it was suggested that the committee take a recess until 2 o'clock p. m.)

Senator DRYDEN. I would like, before that is done, to have Mr. Parsons tell us something in regard to the question of cost.

Mr. PARSONS. The same thing is true in regard to the question of cost. Both estimates were made on substantially the same basis, that is to say, the same basis of unit prices. After they were completed the same allowance was made of 20 per cent to cover the question of general expenses and contingencies.

If you will look at the figures you will see that that extra allowance is very much greater in connection with the sea-level canal than it is with the lock canal; and I believe that in that extra allowance there is a very much bigger margin for contingencies than there is in the smaller amount. In other words, when you get to dealing with constructions of such a vast extent as this, running over \$100,000,000 or \$200,000,000, the contingencies are not in proportion to the total expense—that is, if you are putting up a structure that is going to cost you \$100,000 you might very easily find that some one item was going to run up the expense, but when you come to deal in figures of fifty or a hundred millions you will find that while one item will overrun you will also probably find that other items will underrun, and therefore it is a little unfair to add the same proportion for contingencies in the bigger canal that you add in the smaller canal.

Senator DRYDEN. Have you any information as to the probable damage that the Government might have to pay for lands to be submerged?

Mr. PARSONS. The board tried to make some estimates on that, and finally gave it up as something that could not be estimated. I notice that the minority, however, did attempt to make such an estimate; and they put in their report an estimate of a comparatively small sum of money.

My own experience is that in the question of land damages, where lands have to be taken by condemnation, the cost is always far in excess of the original estimates, and we have already had some experience of our own in that regard in the taking of lands in Panama. If the committee call General Davis, who was governor of the Isthmus for over a year, I think you can get from him some very valuable information on that point, in the way of showing just exactly what lands have cost the United States Government by condemnation as against what those lands were actually sold for by private sale.

I think, therefore, that you will find that in submerging the lands to the extent that the minority plan calls for, there would be a very, very large addition to the estimated expense.

Senator KNOX. What is the character of that land?

Mr. PARSONS. The land itself is, to a great extent, uncultivated.

Senator KNOX. Is it inhabited?

Mr. PARSONS. It is along the line of the railroad; and all the little villages along the lines of the railroad would be submerged.

Senator HOPKINS. Let me ask you right there, Mr. Parsons, if the land does not belong to the railroad company, and if those buildings are not occupied by tenants rather than owners in fee?

Mr. PARSONS. In some cases that is true. In other cases it is not, and you will find that you would have to dispossess a great many of the inhabitants.

Senator KITTREDGE. In either case the land would be lost, would it not?

Mr. PARSONS. In either case the land would be lost; but in the one case you would have to pay for it—you would have to buy it from the present owners; and the experience of the United States Government so far has been very unpleasant in regard to all forced purchases of land.

Senator HOPKINS. Have you any figures, or did your committee make any figures, as to the proportion of land along the railroad there that is occupied by parties where they would have to settle with people who would claim to be owners in fee rather than tenants?

Mr. PARSONS. I think a statement of that sort is incorporated in the report; but the land that is privately owned that would be expensive to acquire is that which lies along the railroad and which would be overflowed by these big lakes, taking the village of Gatun, for instance.

Senator KITTREDGE. In addition to that, Mr. Parsons, the testimony of Judge Magoon is in point.

Mr. PARSONS. And the testimony of Judge Magoon is in point. I think General Davis can give you some figures of lands that we have been obliged to purchase in the neighborhood of Panama; and I think you can see at once there that if that ratio of probable values to actual cost is to be maintained over the rest of the line, there would be a very, very large bill to pay.

The CHAIRMAN. Mr. Parsons, the land purchased there at Panama would be considerably more valuable than that here, would it not.

Mr. PARSONS. It is to be hoped so; or, rather, it is to be hoped that the land you would have to purchase along the Zone would be less expensive land than what you bought in Panama; otherwise you could save a good many hundred million dollars by building a sea-level canal, Senator?

Senator TALIAFERRO. Mr. Parsons, did you read the testimony of Mr. Burr on the question of the value of these lands?

Mr. PARSONS. I do not think I did. I have not seen Professor Burr's third day's testimony. I have had the first two, but I have missed his third day. I came on from New York yesterday, and I think it arrived there yesterday. I think it crossed me.

Senator TALIAFERRO. He thought that the demand for these lands, in case the Government determined to acquire them, would be very extravagant?

Mr. PARSONS. That is what I am saying now. I do not think there is any doubt about that. I think that the estimate that the minority have made is wholly out of proportion—wholly out of proportion.

Senator TALIAFERRO. I think he estimated that the cost of those lands would run up to about eighteen millions on the basis of what the people there have required the Commission to pay.

Mr. PARSONS. We started to make some figures in the board, but we finally gave it up. We found that if we were to take any such ratio as had lately been the rule, it carried us away up into the millions, and we gave it up.

Senator KITTREDGE. How far into the millions, Mr. Parsons?

Mr. PARSONS. We got up into five figures, ten millions and odd, and we stopped. It led us to a figure that was almost ridiculous, and a figure that it would certainly be inadvisable to put in an official report, because it would probably be taken as evidence of what we considered the value of the land—not what we feared the land might cost, but what we considered the value of the land; and, therefore, we decided, as a matter of policy, not to put it in.

The CHAIRMAN. Did you make your estimates on the same basis that you had paid for land about Panama?

Mr. PARSONS. No, sir; because that would have very greatly exceeded the \$10,000,000. We made an estimate as to what land had cost up in that country, and then applied the same ratio of Panama to it. We tried to work it in that way, and then we also took lands where the natives had asked prices, where they had set values upon it as to what they were willing to sell for; but we gave it up as something that it was utterly impossible to estimate.

The CHAIRMAN. There is one question I would like to ask you, Mr. Parsons, just here. Do you recall, without looking, the length of the locks in the Kiel Canal?

Mr. PARSONS. I know just where that information is; I can give it to you in one second, Senator.

The available length is 492 feet, and the width is 82 feet. At the Kiel Canal they have two tidal locks, one at each end, simply to take up the tidal variations in the Baltic and North seas.

Senator TALIAFERRO. Mr. Parsons, was there any division in the Board of Consulting Engineers on the question of the possibility of constructing this sea-level canal on the lines laid down by the board?

Mr. PARSONS. No, sir.

Senator TALIAFERRO. The objections were what?

Mr. PARSONS. The objections were that it would cost too much, both in time and money.

Senator TALIAFERRO. And that it would involve delay to vessels in crossing the Isthmus; but do not the minority contend that the lock canal affords a quicker transit?

Mr. PARSONS. Yes; but I should like to take decided exception to that statement.

Senator TALIAFERRO. Will you explain your views on that point to the committee, if you have not gone over it already?

Mr. PARSONS. I have not gone over it.

The minority gave its views on that subject on pages 85 and 86 of their report; and they have taken for the boats the largest-size passenger steamers passing between western Europe and the Orient through the Suez Canal. Those boats are of two types, one 540 feet long by 60 feet beam by 32 feet draft, and the other 700 feet long by 75 feet beam by 37 feet draft. With ten ships per day of the first type they estimated that it would take eight and nine-tenths hours for that vessel to pass through the sea-level canal, and nine and five-tenths hours to pass through the lock canal. With the larger type vessel, ten vessels a day, it would take eleven and six-tenths hours to pass through the lock canal and ten and five-tenths hours to pass through the sea-level canal; and with thirty ships per day it would take longer, according to their computations, to go through the lock canal than to go through the sea-level canal.

They have assumed for comparison not the ordinary type of ship of commerce, in the first place, but the extreme vessel of the large passenger type, which, in the first place, I do not think is a fair comparison to make. The second thing is that they have assumed all sorts of delays in passing through the sea-level canal; that those vessels have to stop and tie up, and in the lock canal that the locks are all going to work without any delays; that they are all going to be in service, and that the vessels are going to be put through the locks on schedule time.

Senator TALIAFERRO. In other words, they charge delays to the sea level canal, and take ideal conditions for the lock canal?

Mr. PARSONS. And take ideal conditions for the lock canal. I do not think that that is a fair presentation of the case at all.

The ordinary type of vessel, the ordinary vessel of commerce, the ocean tramp steamer (which will form, of course, the great bulk of the travel through the Panama Canal), is a boat that is about 450 feet long, from 45 to 50 feet beam, and that draws from 27 to 28 feet of water. Those boats will be able to pass anywhere in a canal 150 feet in width.

Senator KITTREDGE. At what speed, Mr. Parsons?

Mr. PARSONS. Probably one of them would stop and allow the other to go by at speed, but the present Suez Canal (and in considering this whole question, gentlemen, I do not think I can do any better than to urge you to keep in mind the Suez Canal) has now a width on the bottom of 118 feet and a width in the passing places of 147 feet. That canal is now being widened by connecting the passing places, so that it is to have a bottom width of 147 feet.

In other words, the Suez Canal, when widened, will be narrower than the proposed Panama canal; and they expect that all ordinary vessels will be able to pass through that canal. In other words, they expect that width to make that canal a "double-track" canal.

The CHAIRMAN. Without stopping either one of the ships?

Mr. PARSONS. The ordinary small vessels may expect to go right by without stopping. Other vessels, of course, would have to stop. They would stop one and let the other go by. In other words, vessels going one way would have the right of way.

The CHAIRMAN. When a boat stopped, would it necessarily have to be tied up?

Mr. PARSONS. I think that, again, depends largely upon the size of the vessel. If you are going to pass through two Cunarders, or if you are going to pass through a couple of battle ships, then of course you have to take special precautions, and undoubtedly you would make one of them tie up. Probably a big battle ship going through would insist that all other vessels should be tied up. They steer badly, and especially steer badly, in restricted waters.

The CHAIRMAN. The difference in time, then, in either of the plans is not great?

Mr. PARSONS. The difference in time is not great; but taking the loss of time at the locks in passing through one flight of three locks, one flight of two locks, and a single lock, allowing 50 per cent in addition to the theoretical time, it works out a loss of time of something over four hours (about four hours and ten minutes) in passing through the lock canal.

Senator KITTREDGE. Explain what you mean by that. I do not quite understand where the loss comes in.

Mr. PARSONS. The loss comes in, in the first place, in that a vessel approaching a lock has to slow down; then she has to stop; then she has to start again and enter the first lock; then the gates have to be closed; then she has to be made fast; then the water has to be withdrawn from the locks; then the lines have to be cast off; then the gates have to be opened; then she has to start ahead slowly, and if there are locks in flight she has to move ahead at a very slow speed and stop in the next lock, and then all this operation has got to be repeated.

Each one of those steps takes considerable time, so that (basing the computations upon the computation as given in great detail in the report of the Walker Commission, which you will find fully set forth on page 267 of that report) it would take an hour and thirty-three minutes to pass three locks in flight. In other words, it would take a vessel an hour and thirty-three minutes to go through the Gatun locks, theoretically, and that is substantially corroborated by the Noble-Ripley computation, as given in the appendix to the consulting engineers' report, that vessels could follow in that lock at an interval of fifty minutes, because at the end of the fifty minutes the first vessel would still be in process of locking in the lower lock. So that those two computations are substantially the same.

That is the theoretical time. If, therefore, you add to that 50 per cent to allow for the inevitable delays, that everything will not work exactly on time, it will make a period of two hours and nineteen minutes for a steamer to pass those three locks.

Senator KITTREDGE. And then there would be the same delay on the other side?

Mr. PARSONS. On the other side it would be rather worse. In the first place, the vessel has to pass the double flight of locks, which again (allowing 50 per cent in addition to the theoretical time) would take her an hour and thirty-one minutes. Then she has to pass the single lock, which would take fifty minutes; so that to pass the single lock and the double lock would take two hours and twenty-nine minutes. In other words, it would take her ten minutes longer to pass the separate locks than it would to pass the locks in flight. That is due

to the fact that a vessel in approaching a lock has to slack her speed some distance down before she stops; whereas when the locks are quite close together that loss is saved in passing from one lock to the other. So that altogether the total time taken in passing the single lock, the double lock, and the triple lock would be four hours and forty-eight minutes.

It would take the vessel at her normal rate of speed, say, thirty-eight minutes to pass that same distance if she had been allowed to steam ahead at her ordinary rate of speed. That, of course, is to be deducted. So that the actual time lost can be taken at about four hours and ten minutes as the time actually lost in passing the locks.

Now, then, if a vessel is making 6 miles an hour, you see, she would have gone 25 miles in that time. She would be halfway across the Isthmus in the time that a vessel would take in going through the locks.

Senator KNOX. That does not mean, however, that when vessels are going through a flight of locks there is a loss of service to other vessels for that entire length of time?

Mr. PARSONS. No; as I have pointed out, two vessels could be in a flight of three locks at the same time.

Senator KNOX. Yes.

Mr. PARSONS. But that is the time taken by any single vessel. She loses over four hours in going through the locks of a lock canal.

Senator TALIAFERRO. Is it considered altogether safe, Mr. Parsons, to put two of those large vessels in that flight of locks at the same time?

Mr. PARSONS. No; I do not consider that the three locks are safe at all, gentlemen. I want to be distinct about that. I have kept repeating that. I consider that the three locks in flight are radically and fundamentally wrong. I want to be just as positive on that point as I possibly can be, and I want to say that if the Government undertakes to build locks in flight I want it to be understood here now—I want to go on the record to that effect—that it is against my emphatic protest as a matter of safety.

Senator TALIAFERRO. Are any locks in flight now in use on any of the canals that you know of?

Mr. PARSONS. No; I think on all the big canals they are all separated. Of course on the small canals, where canal boats go through, they are frequently combined, but there there is no great danger. If an accident occurs it does not make any difference.

Senator TALIAFERRO. Was there any exception on the part of the minority to the estimate of cost of this sea-level canal as fixed by the board?

Mr. PARSONS. No; they have made no protest on that in their report, and in our discussions they accepted that as a fair estimate of cost, just as we accept in general the estimate of cost that they have made for their lock-canal scheme.

Senator TALIAFERRO. And, as I understand, the majority rather extended the time that they supposed would be required to construct this sea-level canal, in order to get a unanimity of expression on the subject from the Board?

Mr. PARSONS. We tried to get unanimity of expression on the subject.

Senator KNOX. The situation would be rather hopeless for us, Mr. Parsons, would it not, if upon a given work there should be very much variation in your estimates as to cost?

Mr. PARSONS. Oh, yes. I do not think that there is any difference. As we have stated in our report, independent of the work, a committee was appointed and prepared a statement of the unit prices, as to what were fair prices for the doing of the work. Those prices were submitted to the board and were discussed by the board, and the board made certain amendments, and I think as it appears in the record that report stands practically without amendment. The amendments were made unofficially, the committee accepted the amendments that were made, and incorporated those amendments in the report.

Senator KNOX. Then you substantially agree as to cost and as to time?

Mr. PARSONS. No; the minority differ with us as to the time of building the sea-level canal. They say in their report that they think the majority erred in that respect, and I think they put down a period of fifteen years.

Senator KNOX. Yes.

Mr. PARSONS. They dissented; we failed to get in agreement on that point. We voted unanimously in regard to the length of time it would take to build this lock plan or any lock plan. I do not think the time differs very much in regard to that. So that we agreed unanimously on that, and there is no difference in regard to the total cost of the canal. It may be that individuals will differ in regard to the details. Some of us think that certain details are possibly a little too high or a little too low; but in general, we accept each others' figures in regard to the money cost.

Senator HOPKINS. But you say, Mr. Parsons, that the minority did not accept your figures as to the length of time it will take to construct a sea-level canal?

Mr. PARSONS. No; they say it will take fifteen years.

Senator HOPKINS. And, as I understand, the majority, who united on thirteen years, only took that figure as a compromise among themselves?

Mr. PARSONS. We tried to compromise with the others.

Senator HOPKINS. Yes. Now, you think that eleven years would be a sufficient time?

Senator TALIAFERRO. One moment, Senator, before he answers this question. I want to call his attention to Mr. Burr's testimony on the subject and see if they are in agreement.

Senator HOPKINS. I will develop that.

Senator TALIAFERRO. Go ahead, then.

(By request the stenographer read aloud the pending question asked by Senator Hopkins.)

Mr. PARSONS. I think eleven years is a sufficient time.

Senator HOPKINS. What was the greatest length of time that any member of the majority thought it would take, but finally compromised with you on thirteen years?

Mr. PARSONS. From eleven to twelve.

Senator HOPKINS. How did they compromise on thirteen, then?

Mr. PARSONS. We tried to compromise with the minority.

Senator HOPKINS. Oh, with the minority. I see.

Mr. PARSONS. We tried to compromise with the other side.

Senator HOPKINS. Yes; that was what I was getting at. Then the compromise on thirteen years in your report is not a compromise by the members of the majority?

Mr. PARSONS. No, no. We all added to that in order to try to compromise with the others.

Senator HOPKINS. You fixed on thirteen years and tried to get the minority to do so?

Mr. PARSONS. We tried to get the minority to come down to that figure.

Senator HOPKINS. To agree with you that it would take no longer than thirteen years?

Mr. PARSONS. Yes, and they refused to compromise; but, having offered to compromise, we let it go.

Senator HOPKINS. Yes. What number of years, if you remember, did Professor Burr estimate it would take?

Mr. PARSONS. Ten years; I think he puts it at about ten years.

Senator TALIAFERRO. Mr. Parsons, were not these estimates as to the time required to build the sea-level canal based on the idea that there would be one shift a day of eight hours?

Mr. PARSONS. Yes.

Senator TALIAFERRO. In the first place, can not the work be more rapidly done?

Mr. PARSONS. I think it can be.

Senator TALIAFERRO. And just as cheaply, working two shifts a day, for instance, instead of one?

Mr. PARSONS. I think that any competent contractor who had charge of that work would work at least two shifts a day.

Senator TALIAFERRO. If that were done, would it not reduce the time that you have estimated for the completion of that canal below ten years?

Mr. PARSONS. I think it possibly would; I should be hopeful of it; but I want to state figures that I feel quite sure of. In other words, I want to state such figures that if a party came to me and asked me for my advice as to taking a contract for the doing of that work, I could say to him: "Now, I know it should not cost you more than that, either in time or in money." Then I should go to work and figure on using, the greater part of the year at any rate, two shifts, and endeavor to get the work done in very much less than eleven years of time.

Senator TALIAFERRO. In arriving at this unit of cost, did you consider the additional depth of excavation that would be required in the sea-level plan?

Mr. PARSONS. Yes; and we took that into account all the way through those estimates.

Senator HOPKINS. Did you estimate an increased cost per cubic yard in your excavations as you descended, or was it at the same ratio all the way down?

Mr. PARSONS. The greater part of the excavation, of course, comes in the Culebra cut, and there we assumed a cost of excavation above elevation plus ten, and below elevation plus ten.

Senator KITTREDGE. Explain what you mean by that.

Mr. PARSONS. In other words, above or below a plane 10 feet above mean sea level.

Senator HOPKINS. Yes.

Mr. PARSONS. Above that, the tracks would be running downward, and the material would come down to the sea-level, the level of the

ground below, by gravity. The ground cut could be made to self-drain, and the work would proceed in the simplest possible manner.

Below that plane the excavations would have to be pumped, and the material would have to be hauled up from an excavation to the surface of the adjacent ground, and the work would be carried on within restricted limits, of course adding to the cost.

Senator TALIAFERRO. You considered all that?

Mr. PARSONS. That was all taken into account, and we divided on the plane of 10 feet above mean sea level.

Senator HOPKINS. Have you the figures so that you can tell us to-day what you figured on excavations per cubic yard 10 feet below sea level?

Mr. PARSONS. That is right here. I think I can give you the whole thing.

Senator KITTREDGE. It is in the report, is it not?

Mr. PARSONS. That is all in the report.

Senator HOPKINS. And 20 feet below, and 30 feet, 40 feet, and so on?

Mr. PARSONS. We divided at elevation plus 10; we averaged it all above plus 10 and averaged—

Senator HOPKINS. Leave out that "elevation plus 10." What I want to get at is whether you estimated the expense of the excavation of a cubic yard 20 feet below sea level at the same price that you did the excavation of a cubic yard 10 feet below sea level?

Mr. PARSONS. We averaged everything.

Senator HOPKINS. Did you do that?

Mr. PARSONS. No, sir; we made no attempt to separate it, minus 20 or minus 30 or minus 40, but we took everything below the plane of plus 10 and averaged the cost.

Senator HOPKINS. At what figure did you fix the cost of the excavation of a square yard 10 feet below sea level at the Culebra cut?

Mr. PARSONS. It was \$1.25, I believe.

Senator HOPKINS. One dollar and twenty-five cents a cubic yard?

Mr. PARSONS. Yes, sir.

Senator HOPKINS. Then 20 feet below, how much would it be a cubic yard?

Mr. PARSONS. We estimated it at \$1.25.

Senator HOPKINS. And 40 feet below?

Mr. PARSONS. We estimated it at \$1.25.

Senator HOPKINS. That is what I wanted to get at. That answers my question.

Senator TALIAFERRO. Now, Mr. Parsons, I am going to ask you to explain fully to the committee what you tried to do in answer to Senator Hopkins' question—how you arrived at that; if it was not by an average of the cost from the deepest elevation up to the sea level?

Mr. PARSONS. It was, sir. In other words, for everything below plus ten, the elevation at which we figured we would have to begin to pump, we averaged it down to the bottom of the sea-level canal.

Senator TALIAFERRO. Yes.

Mr. PARSONS. In the same way, for everything above elevation plus ten to the top of the cut, we averaged it. As a matter of fact, any one particular cubic yard at any particular depth would probably not vary very much after you have to establish a pumping plant and after you have to do certain things. The change in cost between removing a cubic yard at the depth of 15 feet and removing one at 25 feet is not very much.

Senator TALIAFERRO. Did the minority apply the same price?

Mr. PARSONS. The minority applied the same price, except that in the Culebra Cut, you see, they did not have any excavation below the elevation plus ten.

Senator TALIAFERRO. They agreed with you?

Mr. PARSONS. Oh, yes; they accepted these figures. These figures that we used, which are set forth in detail in the report, were submitted to the Board as a whole and were discussed by the Board as a whole, and they were finally accepted. Certain amendments were made, but they were finally accepted by the Board as representing our best general judgment.

Senator TALIAFERRO. Under the minority plan for the lock canal, is there any excavation along the line below plus 10?

Mr. PARSONS. Not in the Culebra cut; north and south of the Culebra cut there is. Then we applied different rates there, varying all the way from 15 cents to \$2.50.

Senator TALIAFERRO. You think, Mr. Parsons, of course, that the estimates of cost made by the Board of Consulting Engineers are safe?

Mr. PARSONS. I do not think there is any doubt of it, sir.

Senator TALIAFERRO. They are outside figures?

Mr. PARSONS. I think they are outside figures.

Senator TALIAFERRO. With the work properly done?

Mr. PARSONS. I think they are, with the work properly done. In other words, they are such figures that if anybody came to me to ask whether it would be safe to take that work at those figures, I should say, unhesitatingly, "Yes;" and as that is my business, I want to have those figures safe in giving advice.

Senator KNOX. You mean that you would advise them to take it as a commercial proposition, there being a profit in it to them for doing it at that price?

Mr. PARSONS. Yes, sir; yes, sir.

Senator KNOX. A reasonable profit?

Mr. PARSONS. Yes, sir. In other words, if the Isthmian Canal Commission should advertise for a lump sum bid, for instance (I will take the worst possible case), to construct the canal from ocean to ocean, with the breakwaters and the dams and the locks, etc., I should unhesitatingly advise a contractor to take the contract at the price mentioned in this report.

Senator KITTREDGE. Do you advise the performance of this work by contract?

Mr. PARSONS. Unquestionably, sir.

Senator KITTREDGE. Why?

Mr. PARSONS. For reasons of economy, both in time and money. I think you will get very much cheaper results and I think you will get very much quicker results.

Senator HOPKINS. Then, if it is an economy in money, you would expect that the contract would be taken at less than the figures given?

Mr. PARSONS. I do not think the United States Government, doing it by day labor, can build either canal for the estimate named. I would withdraw those figures if it is to be attempted to be done by the United States Government.

Senator HOPKINS. Then your figures are based on the idea that it is to be done by contract?

Mr. PARSONS. My figures are based on the idea that it is to be done by contract.

Senator TALIAFERRO. But they include a proper and reasonable profit?

Mr. PARSONS. They include a proper and reasonable profit to the contractor. In other words, I consider that those are figures that should be realized if you should ask for bids.

The CHAIRMAN. Would you expect a contractor to use the kind of labor that is being used there now if he should undertake this work?

Mr. PARSONS. I should not want to.

Senator HOPKINS. I take it, Mr. Parsons, that your statement about private contracts and the profit there would be in them would mean that you would give the contractor a free hand in employing his own labor?

Mr. PARSONS. He must have that; he must have that.

Senator HOPKINS. Both as to the character of labor employed and the time that the labor works per day?

Mr. PARSONS. Within, of course, reasonable policing regulations; that they should be properly housed and cared for. That, of course, the Government would naturally insist upon, and very properly insist upon.

Senator HOPKINS. You would not want to limit him to eight hours a day?

Mr. PARSONS. No; I should want to have the right to work at least ten hours a day, and I do not think it is any hardship on a man to work ten hours a day.

The CHAIRMAN. You would want to get your labor where you could get it the best?

Mr. PARSONS. Where I could get it the best; not necessarily the cheapest, but the best.

Senator TALIAFERRO. In arriving at your estimates of cost, you considered that this work was to be done by the labor they have there now, I presume, or you took that into account?

Mr. PARSONS. We took that into account; yes. We assumed that they would have to work largely the laborers there and on the basis of eight hours.

Senator TALIAFERRO. So that better labor and longer hours would correspondingly reduce the time required to build the canal?

Mr. PARSONS. I do not think there is any doubt about that, Senator. In building the subway in New York we had a lump-sum contract, you know, and a fixed time; and the work was completed according to the contract, both as to time and money. Now, if that work had been in my hands to carry out as a city undertaking, with all the restrictions that necessarily go with any public work, I know that I could not have completed the work for either the total cost or within the total time.

Senator KNOX. Do you think it is likely that you could get competitive bids for this work in its entirety on either of these plans?

Mr. PARSONS. I think so.

Senator KNOX. From one contractor?

Mr. PARSONS. I think so.

Senator KNOX. For a lump sum?

Mr. PARSONS. I think so.

Senator HOPKINS. Do you think that would be a better plan than to divide it up into sections and contract for it in that way?

Mr. PARSONS. If I were drawing the specifications for the Canal Commission, I should draw specifications inviting bids both ways, Senator—by sections or as a whole—so that you could get figures both ways. Then you could add up your individual bids and see what they amounted to; and if they were less than your single bid, let it that way, or take whichever way was the most favorable to the Government.

But I believe that you will get bids for the building of that canal in its entirety, and I believe that a single bid would be more economical than a number of bids, because the work could then be run as a whole. If you are going to let part of it to one man, his neighbor will fear that his material, for instance, is going to be carried over his section, and he would have no control over him; and he would therefore do one of two things: Either he would prohibit it, or else he would put in his bid a price that would cover the unknown delays. On the other hand, if one man takes it he goes to work and divides it up and takes care of all those things, which you can not do in the individual bidding.

Therefore I believe it will be more economical to the Government to have one general contract.

Senator HOPKINS. That would be true of either type of canal that is agreed upon?

Mr. PARSONS. That would apply to either type of canal. Then, another thing with a man who has the contract as a whole—his labor problem is very much simplified. One piece of machinery in engaging labor will answer for the whole of the work; and if one part of the work is running ahead and another part of the work is running behind, the labor or the machine plant can be transferred from that which is ahead to that which is behind, and so the work can be brought up.

Senator TALIAFERRO. And it avoids competition for the labor, too?

Mr. PARSONS. It avoids competition for the labor, and it simplifies the whole thing; and I believe that you would get bids for the whole contract.

Senator TALIAFERRO. Have you taken up the question of the dams, Mr. Parsons?

Mr. PARSONS. Not in any detail; no, sir.

Senator TALIAFERRO. Do you consider the dam as proposed by the minority at Gatun, is it not—

Mr. PARSONS. At Gatun; yes.

Senator TALIAFERRO (continuing). Do you consider that a safe dam?

Mr. PARSONS (after a pause). Yes; I consider it as a safe dam. I do not particularly like a dam at that point, but I think that dam will stay there. My objections to the dam are the features that necessarily go with it in the shape of locks, etc. I think the dam will stay. I do not particularly like the dam, but I think the dam would stay. I would rather have a dam in which I knew the water of percolation to be cut off. You are going to get water percolating beneath that dam, and some questions are going to arise. Some of our friends think those questions are very very serious. I do not know that I quite go to the length that some of them do; but when you have a question mark opposite the key detail of your whole structure one naturally hesitates.

Senator TALIAFERRO. You think it would be safer to go down to rock for that dam?

Mr. PARSONS. Oh, you could not go down to rock; it is impossible.

Senator KITTREDGE. If you could, you would?

Mr. PARSONS. If I could, I would—oh, yes; there is no doubt about that.

Senator TALIAFERRO. You did not answer the question. I asked you whether you would consider it safer to go down to rock for that dam.

Mr. PARSONS. As a hypothetical question, yes; but I should like simply to add to that answer that it is impossible to get down to rock. Rock is too far down. If that rock were down 50 or 100 feet, even, I would not hesitate; I should say, "Go right down to rock." In other words, if rock was within a reachable distance, I should go to rock.

Senator TALIAFERRO. You would not fear, with the dam as proposed, any serious underwash?

Mr. PARSONS. If that was the only way—let me put it in this way, Senator, if I may answer your question; then, if my answer is not satisfactory, give me a second try.

Senator TALIAFERRO. Answer it in your own way, Mr. Parsons.

Mr. PARSONS. If the only way to construct the canal at Panama was to build the Gatun dam as planned, I should accept the dam. If there is any other way to build it, I would rather not build the Gatun dam.

Senator TALIAFERRO. And you have pointed out two other ways?

Mr. PARSONS. The more satisfactory way, from my point of view, is not to have any dam at all.

The CHAIRMAN. If you were going to build a lock canal, where would you put the dam?

Mr. PARSONS. That depends again, Senator, upon what kind of a lock canal you are going to build. If you are going to build a lock canal—

The CHAIRMAN. Well, suppose you were going to build a lock canal?

Mr. PARSONS. There are two types of lock canal that you can build. If you are going to build a lock canal as a lock canal I should prefer the type of canal for which I voted in the Board—namely, with a small dam at Gatun, lifting the water, say, 30 feet, and then a second dam in the neighborhood of Bohio, lifting the water 30 feet more.

Those are both dams of moderate height, in regard to which there would be no question at all, because you would not get enough head of water behind either of those dams to make any percolation of any serious amount whatever. You would have, then, perfectly moderate dams that you could build without any question in regard to core walls or going down to rock or curtains or anything else. Then I should put a single lock in the neighborhood of Gatun and a single lock in the neighborhood of Bohio.

There is, however, another type of lock canal—

Senator KITTREDGE. Before you reach that point, you are now describing the plan adopted for comparison?

Mr. PARSONS. I am now describing the plan adopted for comparison. If I were to build a lock canal, that is the lock canal that I should prefer to build; I would separate my locks. I would have one lock only at one place, so that if a vessel should go bucking through, the damage to the canal would be minimized, and the repairs could be made in very much less time.

The CHAIRMAN. How many locks would you have?

Mr. PARSONS. I would have two on each side. I would have one lock in the neighborhood, say, of Gatun, and one lock in the neighborhood of Bohio, lifting 30 feet each. Then, on the other side, I would have a lock in the neighborhood of Pedro Miguel and a second lock on the shores of Panama Bay with a summit level of about 60 feet.

Senator ANKENY. Mr. Parsons, as a factor, what has the wind to do with this flight of locks? You have considered that, of course—the matter of inland winds: are they not going to make it difficult to operate those locks?

Mr. PARSONS. Yes; of course, blowing —

Senator ANKENY. I do not see any report upon that.

Mr. PARSONS. It has not been touched upon.

Senator ANKENY. Is it not very dangerous? Is it not a fact that one of the accidents to these ships that you spoke of was caused by a wind?

Mr. PARSONS. One of them was caused by a gale.

Senator ANKENY. Why have you not considered that matter?

Mr. PARSONS. The majority condemns those locks in toto. I want to say again, and I will take every opportunity of saying it, that I think those locks are thoroughly dangerous.

Senator ANKENY. But is it not a serious matter otherwise? What velocity of wind would suspend your total operations up there in the flight of locks, for instance?

Mr. PARSONS. I do not think you could get a wind up there that would suspend the total operations. It would interfere with the operation of the locks; it would delay matters very much, and might cause an accident.

Senator ANKENY. A 50-mile wind would stop you entirely, would it not?

Mr. PARSONS. I would not like to say it would stop the operation entirely. I would rather say it would interfere very seriously. That lake is sufficiently near the Atlantic Ocean side to get the full blasts of a "norther" howling across there, and in the case of a big steamer approaching a lock with a gale on which would be striking her broadside, or would be glancing off from one of those hillsides, it would make her steer wild, especially at low speeds, and would very seriously interfere with and delay the working of the canal.

Senator KITTREDGE. Was the plan proposed by the minority considered in the Commission?

Mr. PARSONS. The three-lock plan?

Senator KITTREDGE. Yes.

Mr. PARSONS. Yes. They proposed, as you will see by referring to the report of the committee on lock canals—we had three committees on plans arranged, one on sea-level plans, one on lock plans, and one on unit prices. The committee on lock canals submitted four projects to the Board. Project number one contemplated—and I am now reading from the report—"a summit level, at an elevation of 85 feet, to be maintained by a flight of three locks at Gatun on the Atlantic side, and with one lock at Pedro Miguel, and two locks in flight at Sosa Hill, adjoining La Boca pier on the Pacific side."

Now, that was voted down by the Board.

Senator KITTREDGE. What was the verdict?

Mr. PARSONS. The committee itself made no recommendation, as

they were divided. I think we voted on that question something like 9 to 4. We voted that plan down.

Then we adopted, by a vote of 8 to 5, an elevation at plus 60; and in the minority report itself you will find that General Abbot, although he signs the minority report, dissents from this particular arrangement; so that there is a dissenting vote in the dissenting report.

Senator KITTREDGE. So, of the 13 members of the Board of Consulting Engineers, 4 favor the Gatun dam as proposed by the minority, with a flight of three locks?

Mr. PARSONS. Yes; General Abbott dissents from that.

Senator KITTREDGE. When did you first see the report of the minority as presented to us?

Mr. PARSONS. On January 31, the last day on which the board met.

Senator KITTREDGE. And until that time you had no knowledge of the exact plans that they would propose?

Mr. PARSONS. Only in general. I knew that they were going to revert to the project No. 1, which the board had previously rejected, and I am now referring to their minority report, where they state:

"This is recommended for adoption"—

That is to say, the minority plan now under discussion—

"This is recommended for adoption, General Abbot preferring a lower dam with duplicate flights of two locks at Gatun, supplemented by a dam and duplicate single locks at Bohio, raising the summit level to elevation 85, as before."

In other words, General Abbot does not favor the three locks in flight.

Senator KITTREDGE. The report of the majority had been prepared long prior to that date?

Mr. PARSONS. The minority waited for the majority to prepare its report first, and then wrote the minority report without consultation with the majority, of course.

Senator KITTREDGE. And for that reason in the majority report, as I understand, you did not discuss the subject which you are now speaking of, or were speaking of in answer to Senator Ankeny's question?

Mr. PARSONS. No; we rejected the whole thing, and voted for a low lock at Gatun. I will say, in regard to Senator Ankeny's question, that among ourselves we considered the very question that he raised—that is to say, the question of the wind.

Senator ANKENY. But it never was made of record?

Mr. PARSONS. It never was made of record; no. We discussed among ourselves the question of the wind and the effect that it would have upon a ship in a lock 85 feet up in the air within a mile or two of the shore of Limon Bay, where they undoubtedly would get the full force of an ocean gale; and that was one of the reasons for which we rejected the idea of the high-level canal.

Senator ANKENY. But you never set that up in your argument?

Mr. PARSONS. No; this report does not contain all our reasons.

Senator ANKENY. But you looked a little farther than the danger to the ship up in the air there, as you expressed it, 80 feet or more? Is there not a danger to your lock with that immense ship there?

Mr. PARSONS. Senator, we regarded the question of the safety of the canal rather than of the ship itself. In other words, you have now called attention to the views that the majority expressed.

Senator ANKENY. You say that there is great hazard to the ship; but is there not a great hazard to your canal—your locks?

Mr. PARSONS. That is what I have been harping on all along.

Senator ANKENY. But you said the ship.

Mr. PARSONS. I know I said the ship in the first place, because I thought you were referring to the ship, but what we regarded on the question of danger is not so much the particular ship as the danger to the canal.

The United States Government is going to own the canal, and I do not dispute the point that the minority make as to there not being much difference in the danger to the individual ship from Colon in a waterway 150 feet wide, as against the danger to a ship in a canal having locks, with a very much wider waterway between the locks. In other words, it is said that the insurance companies insuring a vessel going through the Panama Canal would probably charge as much insurance for a vessel going through at sea level as they would for one going through the lock canal, and I think there is a good deal in that argument. I am perfectly willing to concede it.

But that does not cover the danger to the canal; and I think you are quite right in the point that you have just made, that the danger to the canal is the important thing, and that the danger to a ship from collision is a comparatively small affair. The vessel might sink; the canal might be blocked for a few days, as here in the recent case at Suez, where a vessel loaded with dynamite was sunk, and I think the canal was blocked for nine days. The ship, of course, was a total loss; but the canal was not damaged.

We are interested here in providing, it seems to me, a canal that should be so far as possible danger proof. In other words, a canal subject to short delays would be a permanent structure, and I do not think a canal laid out with three locks in flight is a permanent structure. The day is coming when those locks are going to be carried away.

Senator ANKENY. Is there not another factor there, necessarily, that those men will not go into those difficulties when the barometer indicates that they are coming on, or something of that sort? Will there not be great delays on that account?

Mr. PARSONS. I think so.

Senator ANKENY. Will you have those delays (which will be important when the shipping increases there as we anticipate it will) in the sea-level proposition?

Mr. PARSONS. No. I spoke a moment ago about the delays in the locks. Now, for instance—

Senator ANKENY. Just let us confine ourselves to this wind issue first. Will the sea-level canal have those delays that necessarily will exist in the lock system?

Mr. PARSONS. No, sir.

Senator ANKENY. From winds?

Mr. PARSONS. No, sir; a vessel once in past the breakwaters at Limon Bay can proceed right through the canal.

(At this point it was suggested that the committee adjourn until to-morrow morning at 10.30 o'clock.)

The CHAIRMAN. Now, gentlemen, Mr. Parsons has given us his opinion in regard to this matter in such a way that there is no misunderstanding his position in reference to it. I do not know whether

we want to detain him any further or not. I certainly understand Mr. Parson's position. If other Senators would like to have him stay over and come before us to-morrow at 10.30, of course we will ask him to do so.

Senator TALIAFERRO. Mr. Parsons, have you stated all that you wish to put before the committee?

Mr. PARSONS. Why, Senator, I am at the service of the committee. I have put myself on record in signing the report. I have placed my views in that report, and if the committee want to go ahead and examine me as they have been doing this morning I will come back this afternoon, or I will stay here until to-morrow. I am entirely at the service of the committee. It is for you gentlemen to say what you want to do with me.

Senator KNOX. You have nothing yourself that you wish to volunteer in addition to what the report contains, as I understand, but you are willing to illuminate the report by further explanation if desired?

Mr. PARSONS. I am willing to illuminate the report by any explanations you gentlemen would like to ask for.

Senator KNOX. But the report shows your whole position?

Mr. PARSONS. I stand by the report. I stand by the report, and stand against the minority report. In the first place, the structure proposed is not, in my judgment, a safe one. In the second place, it does not comply with the requirement of Congress that it should be able to take not only the largest existing vessels, but such increase in the size of vessels as can reasonably be foreseen.

Senator ANKENY. You are too good a logician, Mr. Parsons, to attack all these matters without suggesting a remedy. You say these things are dangerous. Now, you have a plan that you consider not so dangerous?

Mr. PARSONS. Yes, sir.

Senator HOPKINS. That is set forth in the report of the majority?

Mr. PARSONS. That is set forth in the report of the majority. If you are going to build a lock canal—the Chairman asked me, if I may take up your time one moment, Mr. Chairman——

The CHAIRMAN. Certainly, Mr. Parsons.

Mr. PARSONS. You asked me a question about what I would do. I say that if you were going to build a lock canal I should prefer the lock canal that I voted for in the Board—namely, one with single locks.

The CHAIRMAN. Yes.

Mr. PARSONS. Of course there is another type of lock canal which was advocated in the Board which does not appear on the record, about which Professor Burr himself made a suggestion, as I see, in his testimony—namely, the possibility of putting locks immediately adjacent to the Culebra Cut. In other words, that plan contemplates building the sea-level canal from both ends just as far as you can build it, until you strike the rise of the mountains, and then putting locks there.

If you are going to build a lock canal with a view to its subsequent transformation into a sea-level canal, that is the kind of a lock canal to build. While it is a lock canal it will not be as good a lock canal as the one that I have just referred to, which represents the views of the majority of the Board—namely, a 60-foot level with a certain amount of lake space. There is an advantage in having lakes.

The CHAIRMAN. Mr. Parsons, right there do you think that a lock canal built on the idea that you suggest, with four locks, could be

built for the same amount of money as that recommended by the minority.

Mr. PARSONS. No, sir; it will cost you more money. The estimate is given in here, I think, at \$175,000,000 or \$176,000,000. It will cost you more money, but it will be a very much better canal.

Senator TALIAFERRO. You mean more money than they estimate?

Mr. PARSONS. No, sir; the estimate is given here at a cost, I think, of \$176,000,000.

Senator TALIAFERRO. I say, you say that that canal will cost more than the canal of the minority?

Mr. PARSONS. Oh, yes; it will cost more than the canal of the minority.

Senator TALIAFERRO. Do you mean that it will cost more than that canal will cost, or more than it is estimated that that canal will cost? Professor Burr thought that canal would cost more than they estimated, including the purchase of these submerged lands.

Mr. PARSONS. Oh, none of these estimates include the submerged lands at all. I am afraid of that submerged land question. As I said a few minutes ago, I think those submerged lands will run the cost to very extravagant figures. I think that the minority will be very much surprised, and I think that the United States Government will be very much disappointed in the cost of those lands; and therefore the lower level plan would diminish the amount of land to be taken.

(The Committee thereupon adjourned until to-morrow, Wednesday, March 14, 1906, at 10.30 o'clock a. m.)

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Wednesday, March 14, 1906.

The committee met at 10.30 o'clock, a. m.

Present: Senators Millard (chairman), Dryden, Hopkins, Knox, Ankeny, and Morgan.

STATEMENT OF WILLIAM BARCLAY PARSONS, ESQ.—Continued.

Senator KITTREDGE. Mr. Parsons, during the hearing yesterday some member of the committee asked you to prepare, if you found time, a map showing the condition of the hill in the vicinity of the Gatun locks as proposed by a minority of the consulting engineers. Have you prepared such a map?

Mr. PARSONS. I have, sir.

Senator KITTREDGE. Will you produce it and explain it to us?

Mr. PARSONS (producing map). The map which I laid before the committee yesterday was plate 11 of the report, showing the Gatun dam and the three locks in flight, all shown in red; and I think it was Senator Dryden who asked me if I would make a section of the hill. The Gatun dam is shown in red, with the three locks shown in series at the side of the dam. The black lines indicate the contours of the hill, and you will see that the approach works on the south end, the lake end of the locks, are brought right out to the very edge of the hill; and, in fact, the center guide wall projects over the side of the hill, and it is that that Mr. Bates referred to in his testimony that the approach wall would have no support at all. Of course he meant by that that you would have to put in a very deep support. It would not have a natural support, and you would have to build down to the ground.

Senator MORGAN. Which plan is that?

Mr. PARSONS. This is the minority plan. This is in answer, I think, Senator, to a question that was asked after you had left the room yesterday. Senator Dryden, I think it was, asked if I would prepare a section through that hill showing just how those three locks lay with respect to the hill. The locks are fixed at this end, and the head works project right out to the very edge of the hill. I have drawn here, in a great hurry, since the meeting yesterday, a section of the hill as taken from the official topography and the borings that were made on the site. The details of those borings are given in other plates in the report.

Senator KITTREDGE. How many borings were made in the Gatun Hill in the vicinity of where the locks are to be placed?

Mr. PARSONS. There were nine borings made, I think, Senator, on a different location. This map shows them. There were seventeen borings made altogether, and it was figured at that time that the locks should take that direction, as you can see by these black lines [indicating on map].

Senator MORGAN. The seventeen borings were on the lock site?

Mr. PARSONS. On that lock site; not on the lock site that was finally adopted. The seventeen borings were made on the first lock site as proposed by the committee. Then they found that the hill in that direction was too short to accommodate the locks, and the location was therefore changed from the black lines to the red lines, as indicated on this map, in order to get a longer run of hill, so that these borings down here [indicating on map] give no information at all as to the condition of the lock farther to the east. Therefore, as a matter of fact, there are four borings, or three really, that come within the lines of the lock, as shown by the minority report.

Senator MORGAN. The official location is indicated by those three red lines?

Mr. PARSONS. The official location is indicated by the three lines, and they are outside of the information gathered by the borings; so that there are only three borings that come within the lines of the locks.

Senator HOPKINS. How far out are they, Mr. Parsons?

Mr. PARSONS. That distance is 500 feet [indicating by scale on map]. You can see that all these borings down to the west of the canal, on the lower part, are from 500 to 1,000 feet away.

Senator HOPKINS. From the actual location of the locks?

Mr. PARSONS. From the actual location of the locks. And if you will refer to the plates showing those borings there, given in the report, you will see the indurated clay, for instance, which is the material on which they expect to found the locks, and how it will vary in position between two borings. You see it is liable to fluctuate very widely.

Senator KNOX. It is liable to fluctuate widely within what distance?

Mr. PARSONS. Oh, in a distance of two or three hundred feet it would fluctuate very widely. That is to say, that in order to get anything like an accurate knowledge of the material there on which to found a structure like these locks, borings should be made very close together, as was in fact proposed here. You can see how close the borings were made there [indicating], and on the site of the locks no borings were made at all.

Senator HOPKINS. Before you leave this point, on that map it looks as though those hills run back there, and as though the locks could be run back.

Mr. PARSONS. The ground is too high. If you start to go through that hill, that would be very very expensive. You take these locks, as shown in three steps in pencil on this drawing, and if they were to be made a thousand feet long—and these steps are taken exactly from the plan given in the report—you would have to bring the lower ends of the locks down here, in this direction (it is really going to the north, but it is low, so far as the elevation of the ground is concerned); they would have to be moved down here some 750 feet, and you would get 2,000 feet away from the last boring, which is this one [indicating]; and there is no knowledge at all as to what the hill contains there.

So, whether you would get any foundations for the lock at the north end, there is no information at all.

I should like to state, however, that this is in answer to the questions that were asked me yesterday in respect to Mr. Bates's testimony, and that my own belief is that those locks can probably be constructed. I am not attacking the ability to construct those locks at all. I want to have that distinctly understood. But at the same time, if the locks are built, when they are built they will be unsafe for operation, in my opinion, as I explained yesterday. In other words, I lay stress not upon the inability to construct the locks or the inability to make those locks 1,000 feet long if necessary. I believe that the ground is probably there to build the locks on, and that the locks can be built a thousand feet long if it is necessary, but that if that is done you will still have locks that are unsafe to operate, on account of the locks being in series of three.

Senator MORGAN. On the plan laid down or proposed by the minority of the committee and also by Mr. Bates for a dam at Gatun, they correspond, as Mr. Bates stated, precisely in the axis of the dam. I wish you would describe the country as it is now, lying between the abutments of that dam. What is the width between the abutments of the dam across there?

Mr. PARSONS. Senator, I shall have to scale that on the map, because I do not carry those figures in my mind. [After measurement on the map.] The valley across which this dam is to be thrown is flanked on two sides by the hills, as shown on the plan here, with a hill in the center, like an island, so that there will be really two dams. Although the structure will, of course, run clear through from hill to hill, as a matter of fact it really becomes two dams. It is about 7,000 feet from one end of the dam to the other.

Senator MORGAN. Is the opening that is to be closed by the dam there by Mr. Bates or the minority of the Commission—

Mr. PARSONS. Mr. Bates does not propose as high a dam as that. Consequently—

Senator MORGAN. I understand; but that is the area that is to be inclosed?

Mr. PARSONS. No; Mr. Bates wants to put his dam farther to the north, Senator. He proposes to close the valley nearer the Limon Bay.

Senator HOPKINS. He has two dams?

Mr. PARSONS. Yes, sir. He has a smaller dam in here [indicating on map]. His main dam he puts down here [indicating on map].

Senator MORGAN. He stated that the axis of his dam across the Chagres River was the same as that of the minority of the committee.

Mr. PARSONS. If Mr. Bates said so, of course he knows his own plans. He puts a subsidiary dam at Gatun. His main dam he puts down below.

Senator MORGAN. His dam was much lower than theirs?

Mr. PARSONS. Yes, sir.

Senator MORGAN. I want to get at this: I suppose that from the eastern side of the Chagres River a ridge breaks in—an upland?

Mr. PARSONS. Yes, sir.

Senator MORGAN. When you arrive at the Chagres River or in the vicinity of it, does that ridge show a rock front?

Mr. PARSONS. No.

Senator MORGAN. There is rock in that ridge east of the Chagres River?

Mr. PARSONS. Probably; but if you will refer to these borings you will see that you strike a very hard clay, called indurated clay. It is a clay that looks like a rock, but it is not a rock.

Senator MORGAN. I am speaking now of the shores, the coast of this depression.

Mr. PARSONS. There is no rock outcropping that I have ever seen.

Senator MORGAN. There is no rock in the entire extent of that ridge that runs in the direction of the Chagres River from the east?

Mr. PARSONS. I have never seen any rock there.

Senator MORGAN. Is there any in the next hill or mountain or whatever you please to call it?

Mr. PARSONS. I believe not.

Senator MORGAN. Is there any in the second ridge that you strike coming across?

Mr. PARSONS. There on the west side?

Senator MORGAN. Yes.

Mr. PARSONS. Yes; in cutting through the diversion of the Chagres River they showed up rock on those hills over there.

Senator MORGAN. In this interval there have been borings made along the axis of the canal proposed by the minority down to the rock?

Mr. PARSONS. They have gone down to what they call an indurated clay. They have not developed the rock in the line of that dam in the bottom of the geological valley there.

Senator MORGAN. Does anybody know whether that indurated clay has a foundation upon rock?

Mr. PARSONS. I do not think it is known. I suppose it has a foundation on rock somewhere, but they have not gone through the indurated clay to find it.

Senator MORGAN. They have gone 285 feet?

Mr. PARSONS. Yes, sir.

Senator MORGAN. Without striking rock?

Mr. PARSONS. Without striking rock. They ran through clay, clay and wood, and clay and sand.

Senator HOPKINS. Did they go down 285 feet or 258 feet?

Mr. PARSONS. Two hundred and fifty-eight feet, I think it is.

Senator MORGAN. Two hundred and fifty-eight feet; yes. I had the figures reversed. So far as the engineers know there is no rock foundation underneath that indurated clay. The whole dam rests upon that foundation of indurated clay.

Mr. PARSONS. No, Senator. The whole dam would rest upon the material overlying the indurated clay, because they do not propose to go through the overlying material to the indurated clay.

Senator MORGAN. It rests upon the indurated clay and the mass that lies above it, then?

Mr. PARSONS. Precisely. And they propose simply to remove the loose top soil and then make an earth dam directly on that material.

Senator MORGAN. Do these borings indicate that they pass through soft material and through wood before they reach the indurated clay? Is that true?

Mr. PARSONS. That is true.

Senator MORGAN. What is the depth of the mass that lies above the body of indurated clay to the surface of the water, or near to it, we will say?

Mr. PARSONS. The deepest hole that was found on the line of the canal was 258 feet below water level.

Senator MORGAN. And that only reached the indurated clay?

Mr. PARSONS. That only reached the indurated clay.

Senator MORGAN. The balance of it, then, is this mass of matter that is composed of various descriptions of material?

Mr. PARSONS. Yes; I will read the materials shown by the borings. [Reading:] Sand and clay—

Senator KITTREDGE. From what plate are you reading?

Mr. PARSONS. Plate 12 [reading]: "Sand and clay; clay and wood; clay; sand, shells, and wood; sand and shells; sand and gravel."

Senator MORGAN. At Bohio, and perhaps farther down the course of the river, the engineers, who have heretofore explored this region with boring drills and implements have discovered what they call a geological gulch or "V?"

Mr. PARSONS. Yes, sir.

Senator MORGAN. Is that same gulch discoverable or has it been discovered at the site of the Gatun dam, that is proposed by the minority of the committee?

Mr. PARSONS. Yes, sir. If you will refer to plate 12 you will see that gulch shown there in the lower profile [showing profile to Senator Morgan].

Senator MORGAN. How do they know it is there unless they have bored down to it?

Mr. PARSONS. They have bored down to it. I was just reading the materials obtained from the borings there lying above the indurated clay. There is the gulch there [indicating on map].

Senator MORGAN. That gulch is formed in indurated clay and not in rock?

Mr. PARSONS. Yes, sir; in indurated clay and not in rock.

Senator MORGAN. And there is no rock basis there for that gulch?

Mr. PARSONS. It has not been found.

Senator MORGAN. But an actual rock basis for that gulch has been found at Bohio?

Mr. PARSONS. Yes, sir; they found the rock there.

Senator MORGAN. So that, between Bohio and Gatun, there is as yet no development by the borings that have been made of the extension of that geological gulch formed in the rock in the direction of Gatun?

Mr. PARSONS. The borings do not show the depth of the rock. At Gatun the borings were put down until they struck that indurated clay, and then stopped.

Senator MORGAN. I notice a precipitous figure there on that profile—a sort of gulch.

Mr. PARSONS. Yes, sir.

Senator MORGAN. That means, if I understand it, that the indurated is found, for instance, at this level on this side [indicating on profile] and at this level on this side [indicating]?

Mr. PARSONS. Which is about 25 feet above sea level.

Senator MORGAN. And on this side it is not found until you get to the bottom of this boring [indicating on profile]?

Mr. PARSONS. That is correct; 258 feet below sea level, or a total drop of 285 feet.

Senator MORGAN. This bed of indurated clay may be stated to form the walls of this gulch in here [indicating on profile]?

Mr. PARSONS. That is correct.

Senator MORGAN. I have inquired of a man that I have a great deal of respect for as an engineer, and I think he is as great a man as any in the world in that regard, and I want to read to you his criticism upon that situation, just to see whether you concur in it or not. I will not give his name. I do not feel at liberty to do it, because I asked him for his opinion (reading):

"I can not reconcile myself to the proposition of resting the enormous interests involved in the proposed waterway on the problematical stability of an experimental earth dam resting on river silt 258 feet deep; and I believe that many engineers will agree with the majority of the board in doubting the impermeability claimed for a soil composed of silt, shells, sand, clay, decayed wood, and other débris brought down by the river and promiscuously deposited, when subjected to a pressure of 85 feet depth of water. That no appreciable leakage will take place under the dam is at best a matter of opinion, which can not be proved by mathematical computations or by established engineering experience. That highly compressive soil must sink to a great extent under the weight of the embankments, amounting to 7 or 8 tons to the square foot, exclusive of the weight of the water.

"The settlement will continue for a number of years, and will be unevenly distributed in the deep gorges and in the dam as a whole, by reason of lack of uniformity in the sustaining subsoil. As the gorges are confined by nearly vertical rocky cliffs, extending to great depths, breaks or disintegration must be expected in the embankment at the crests of these four cliffs, that position of the embankment, resting on solid ground remaining practically stationary, while the sections on top of the gorges slide down along the rocky walls. Such disturbances must cause breaks in the dam at those points, through which a stream of water, very small at first, may find its way, and which all engineers know will, under the proposed head of water, end in a disastrous breach in the dam.

"A failure of the dam by such natural processes as here described, or the destruction of the controlling works of the flight of locks by the fire of an enemy's ship from 4 miles at sea, would precipitate a tidal wave of enormous power of destruction to the canal and whatever may be found between those works and the sea. It is true that with a lake of 108 square miles of superficial area, as is proposed to be created by dams projected at both ends of the canal, the flood waters can be kept under control so far as violent fluctuations of level and gradual discharge of the surplus water are concerned, but cross currents, silting up, and changes in location of the navigable channel must be expected, and the high speed in vessels through the locks estimated in the report will, in my opinion, prove more theoretical than practical. This objection applies with greater force to that portion of the lake between Obispo and the Gatun locks, a distance of 23.5 miles, in which the highest speed and freedom of navigation are expected to be attained."

That is as much of that letter as I desire to read to you. I wish to know to what extent, if any, you concur in those opinions.

Mr. PARSONS. I concur substantially in the whole of those opinions, Senator, as indicated by my vote on the Board when I voted against the Gatun dam and against the flight of three locks. As I said yesterday, I consider that arrangement a very dangerous arrangement.

Senator MORGAN. I wish to state that this is from a gentleman who has no connection with any of those plans.

Mr. PARSONS. There is one point in his letter that I would like to call attention to. He speaks about whether that material was permeable or not. I think that this committee has before it a blueprint showing all the data connected with these holes which, by some accident, was left off of plate 12, in which water flows from those holes and above the surface of the ground, indicating not only that there is water there, but that there is water there in motion; otherwise of course it never could flow out of the tops of the holes.

Senator MORGAN. Did the water that came out of those pipes flow continuously in the borings through what is called the indurated clay?

Mr. PARSONS. No, sir; there were no borings made through the indurated clay.

Senator MORGAN. Only into it?

Mr. PARSONS. The flow came from the material overlying the indurated clay.

Senator MORGAN. So that there is nothing to show that the indurated clay is permeable?

Mr. PARSONS. The indurated clay is undoubtedly impermeable.

Senator MORGAN. All right.

Mr. PARSONS. But the material lying above the indurated clay is not, and water flowed from a number of these holes, as you can see by this map, Senator [indicating on map].

Senator MORGAN. These are the holes the water flows through [indicating]?

Mr. PARSONS. Yes, sir. This profile that you have before you is the original paper that was sent from the Isthmus to the Board of Consulting Engineers, of which plate 12 is a partial copy.

Senator MORGAN. The water flows through these borings?

Mr. PARSONS. It is marked on here where the water was found. For instance, there was water found at that point in that hole [indicating], and at that point in that hole [indicating], and therefore in that particular hole water flows from two different strata.

Senator MORGAN. But in like manner?

Mr. PARSONS. The profile indicates all these holes where the water is coming from and in nearly every hole water flowed up over the top of the pipe. In other words, it indicated that there was water in all this sandy strata and water under pressure sufficient to make it rise to above sea level.

Senator MORGAN. Here is a very close correspondence between this level [indicating on profile] and this [indicating].

Mr. PARSONS. Yes.

Senator MORGAN. Where water was discovered.

Mr. PARSONS. Yes.

Senator MORGAN. But in the interval is a ridge, I will call it, an uplift or ridge, of the impermeable material?

Mr. PARSONS. Yes, sir.

Senator MORGAN. Is there any impression amongst the engineers that the water that appears here and the water that appears here and the water that appears here [indicating on profile] is the same?

Mr. PARSONS. It is undoubtedly the same, meeting higher up. This block of indurated clay is probably a geological island, and those two

gorges that you see on this profile probably join at some point to the south of that island. For instance, you can see the same thing topographically on this map on the wall as appears geologically on that map there. Here is this island, in between these two streams [indicating on map]. Geologically, beneath the surface, you have practically very much the same arrangement as above the surface there.

Senator MORGAN. It is therefore possible, if not probable, that the water that is found coming into the tubes at about the same elevation in each side of this ridge is the same water connected beneath an island, if I understand you?

Mr. PARSONS. Undoubtedly the same water.

Senator MORGAN. So that from this point to that point [indicating on profile] there is some current of water passing underneath that permeable material?

Mr. PARSONS. Passing around. It does not go underneath the permeable material. It does not go through the impermeable material, but it goes around it. They probably both have the same source, namely, the water in the Chagres River at some point higher up the valley, so that that material is permeable.

Senator MORGAN. In basing a dam upon this impermeable material you would necessarily have to make provision to prevent this flow of water that goes around it and appears at the same level on either side of it? You would have to provide against that?

Mr. PARSONS. The minority does not propose to provide against that; and, in fact, it is impossible to provide against the undercurrent of water in that permeable material.

Senator HOPKINS. In your judgment, would it be necessary to do so?

Mr. PARSONS. It would be very desirable to do so, Senator. I would rather put it in that way. It would be very desirable.

Senator HOPKINS. The tendency of time is to fill these pockets with the material that comes down the Chagres River, is it not?

Mr. PARSONS. They have not been filled so far, Senator.

Senator HOPKINS. Is not the fact that these are pockets and that you have this island that you speak of an evidence of the fact that it is being filled?

Mr. PARSONS. No, sir. That indurated clay is not working out. The probabilities are that that hole was indurated clay at one time and the river has dug out those pockets; that the river has been flowing down there. That has undoubtedly been washed out. Then there is some general subsidence of the surface of the ground. The whole country has gone down, and, as it went down, the river has filled up these pockets, which it had theretofore excavated, in some previous geologic period, and it has filled them up with such loose material as it had at hand to bring down. Therefore it has filled them up with clay, gravel, wood, and so forth.

Senator HOPKINS. The tendency is to solidify that material in those pockets all the time, is it not?

Mr. PARSONS. I do not think so.

Senator DRYDEN. Would it not be possible to divert this water which flows down into these pockets at some point above, so as to make another disposition of it?

Mr. PARSONS. No, sir; you can not cut that off. The whole Chagres Valley has a great geological valley on its own bottom, just like that, and that extends all the way up to the main divide.

Senator MORGAN. I have a single question to ask, and I should like to ask it, and then turn the witness over to my colleagues.

You say, Mr. Parsons, that is the base of the dam, is it, or about there [indicating on map]?

Mr. PARSONS. Yes, sir.

Senator MORGAN. It is impossible in the construction of that dam to fill up these channels, that appear on both sides of that geological island, so as to stop the flow of the water?

Mr. PARSONS. Practically impossible.

Senator MORGAN. Is it probable that that same channel will fill up by the silt that comes out of the water of the river?

Mr. PARSONS. No, sir; I do not believe that those underground channels will ever close up.

Senator MORGAN. So that they will remain there?

Mr. PARSONS. I think so.

Senator MORGAN. You will have to build your dam with the expectation of their remaining there?

Mr. PARSONS. Yes, sir; and a certain amount of water will always pass beneath that dam.

Senator MORGAN. With an 80-foot head of water, or a great head of water above that at the dam, would not the flow through those channels be very much increased?

Mr. PARSONS. Undoubtedly.

Senator MORGAN. And there would be great pressure there?

Mr. PARSONS. Undoubtedly.

Senator MORGAN. Would not that be an element of threat or danger to this dam always?

Mr. PARSONS. Undoubtedly.

Senator KNOX. Right in that connection, because it is a part of the same subject, is there a sufficient amount of water, in your judgment, flowing through those channels to affect the stability of the dam?

Mr. PARSONS. As I said yesterday, Senator, I believe that dam will be stable, even under those conditions. It is a dam that I would rather not build, but if it was the only way to build the Panama Canal I would build the dam that has been proposed by the minority. I do not believe in the arrangement of the dam, and the most objectionable feature is the one I explained yesterday in connection with the three locks.

Senator KNOX. I understand that view thoroughly. I only wanted to be satisfied in my own mind about the question of stability.

Mr. PARSONS. I believe that the dam will be stable. It is somewhat conjectural, but I believe that with proper care the dam would be stable——

Senator MORGAN. How could that geological island exist in there except by being separated from a former continuous body of impermeable or indurated clay, of which it is composed? How could it exist there except by some convulsion of nature, or the washing of the water around it?

Mr. PARSONS. It was probably made by erosion, Senator.

Senator MORGAN. By the erosion of the water?

Mr. PARSONS. By the erosion of the Chagres River.

Senator MORGAN. That is the probability?

Mr. PARSONS. Yes, sir.

Senator MORGAN. As long as the erosion kept up the danger would be there, whatever it may be?

Mr. PARSONS. But when that erosion took place it is also probable that the surface of the ground was quite different from what the surface of the ground is now.

Senator MORGAN. I suppose nobody knows whether that indurated clay is a deposit from water or whether it is the original formation of the earth there?

Mr. PARSONS. I would not like to express any opinion on that.

Senator MORGAN. Nobody knows?

Mr. PARSONS. I do not want to say what anybody else knows. I do not know, Senator.

Senator MORGAN. You do not know? You have thought over this subject?

Mr. PARSONS. I have.

Senator MORGAN. And you can not inform this committee whether that body of impermeable or indurated clay is a part of the original structure of the earth or whether it has been deposited there by the action of the water?

Mr. PARSONS. Probably, like all clays, it is a matter of deposit in water.

Senator KITTREDGE. Mr. Parsons, I would like to ask you about the Gamboa dam, whether in your judgment it is an entirely safe structure, and whether its construction involves any unusual or untried engineering problems?

Senator HOPKINS. Point out Gamboa on the map there, in the first place, please.

Mr. PARSONS. There is the Gamboa dam, right there [indicating on map]. And that Gamboa dam makes that lake, as indicated in blue on that map.

The dam as proposed at Gamboa is a perfectly safe structure, and it will be built in accordance with well-recognized engineering principles.

Senator KITTREDGE. What advantages, if any, has the construction of that dam in the way of furnishing power for any purpose useful in connection with the operation of the canal?

Mr. PARSONS. The Chagres River is to be controlled by the Gamboa dam, and a certain amount of water will have to be let through that dam always; more, possibly, in times of flood, but there is always a certain amount of water that will have to pass through that dam, and will have to pass through the dam at a considerable elevation. It will therefore be perfectly possible to put a power house there, and, instead of having that water go idly into the river, to let it pass through turbine wheels and generate electricity for use.

Senator KITTREDGE. And what useful purpose will that accomplish?

Mr. PARSONS. There will be sufficient water going to waste through the Gamboa dam to provide power to operate the canal with whatever necessary machinery may be in connection with the canal, as, for instance, the machinery to work the tidal locks at Panama, and to light the canal and the terminal harbors; because if the canal is to be operated by night, the whole length of the canal must be lighted. There would be enough power, in addition to that, to operate the Panama Railroad, and, probably, to light the cities of Colon and Panama.

Senator MORGAN. That is a map of the proposed sea-level canal, is it [indicating map on the wall]?

Mr. PARSONS. It is.

Senator MORGAN. I notice that there are several curves between Gamboa and the Bay of Limon which might possibly retard or interrupt to a certain extent the safe and rapid navigation of the canal. Is it practicable within reasonable cost to take out the sharpest of those curves?

Mr. PARSONS. No, sir; it is not, but you must remember that the radius of the sharpest curve is 8,200 feet—more than a mile and a half—and that that curve is very, very much flatter than the curves that are found at Suez, at Kiel, or at Manchester.

Senator MORGAN. Well, the ideal or the really desirable canal is a straight line?

Mr. PARSONS. Certainly.

Senator MORGAN. But you think that the line as projected by the majority of the consulting board, of which that is a map, could not be improved without great expenditure of money?

Mr. PARSONS. Substantially not.

Senator MORGAN. And that there is no necessity for improving it?

Mr. PARSONS. There is no necessity for improving it. You will have a canal on that alignment that will be far more easily navigated than any of the ship canals that have been built in the world to-day, and which are operated with entire satisfaction.

Senator DRYDEN. At the sharpest turn in that canal, how far apart do you think two approaching vessels could see each other?

Mr. PARSONS. I could not answer that question definitely, Senator. It depends upon the local topography; but they would undoubtedly be able to see each other a long ways off, quite far enough off to prevent any possibility of collision.

Senator DRYDEN. A quarter of a mile?

Mr. PARSONS. Oh, yes; they would be able to see each other farther off than that. They would see the masts farther away than that.

Senator DRYDEN. In connection with that point, is this territory down there subject to fogs particularly? Do you know whether that is so?

Mr. PARSONS. Not to any very great extent. I never have seen any fogs there.

In regard to this question of curvature, Senator, about which you were asking a moment ago, I have prepared a little table this morning which I would like to submit in answer to your question, as showing the characteristics of the Suez, Kiel, and Manchester canals, as compared to the proposed sea-level canal. Taking the minimum bottom width at Suez, it is 108 feet; at Kiel it is 72 feet; at Manchester it is 120 feet, and at Panama 150 feet. Depth: Suez Canal, 31 feet; Kiel, 29.5 feet; Manchester, 26 feet; Panama, 40 feet. The radius of the minimum curve at Suez is 6,561 feet; at Kiel, 3,282 feet; at Manchester, 3,100 feet; at Panama, 8,200 feet.

At Suez there are seven curves which have a radius less than the minimum radius as proposed by the majority. Therefore you will see that the bottom width at Panama is 50 per cent greater than that at Suez, while the depth is 30 per cent greater and the minimum curve is 40 per cent greater. I think it is well to keep Suez in mind, because there is a canal which has been operated, now, for a great many years, and you can see that the dimensions which have been given by the

majority in the sea-level plan are vastly in excess of the similar dimensions as found at the Suez Canal.

Senator KITTREDGE. I was about to ask you, Mr. Parsons, what great dam you are now engaged in constructing?

Mr. PARSONS. I am consulting engineer and chairman of the board of engineers building a dam at McCall's Ferry, across the Susquehanna River, and preparing plans for a second dam across the same river immediately below that. The dam has a length of about 3,000 feet on the crest, and with a head of about 75 feet, all in masonry. As compared with the Gamboa dam, it is a very much larger structure; and comparing the Susquehanna River, with which, of course, you are all very familiar, with the Chagres River, the Susquehanna River has, in times of flood, ten times the maximum flood that has been known to pass the Chagres at Gamboa. There has been a flood in the Susquehanna of over 700,000 cubic feet a second. Floods of 500,000 feet a second are quite common.

Senator KITTREDGE. Where on the Susquehanna is the dam you have mentioned?

Mr. PARSONS. At a place called McCall's Ferry.

Senator KNOX. And where is that?

Mr. PARSONS. About 40 miles up the river from Havre de Grace.

Senator KNOX. Oh, yes.

Senator KITTREDGE. Yesterday we were discussing, as the adjournment was taken, the question of the speed of ships—

Senator HOPKINS. Before you leave that, are there any locks connected with that dam that you were just speaking of?

Mr. PARSONS. No, sir; that is simply a dam for power purposes.

Senator HOPKINS. For storing water?

Mr. PARSONS. For storing water for power purposes. I did not mention it yesterday when I was giving my autobiography. The Senator asked about that dam, I presume, in comparison with the Gamboa dam.

Senator KITTREDGE. Yes; that was the purpose.

Mr. PARSONS. The difficulties in damming the Susquehanna River are far greater than those of damming the Chagres River.

Senator ANKENY. Has that dam that you are building across the Susquehanna a stone core with earth filling?

Mr. PARSONS. No, sir; that is an all-masonry dam, because the whole river will have to pass over the top of that dam at times of flood.

Senator ANKENY. This dam that you contemplate has what you call a stone core?

Mr. PARSONS. At Gamboa?

Senator ANKENY. Yes.

Mr. PARSONS. The estimates that were made are sufficient to cover either an all-masonry dam or a dam with a masonry core and earth on both sides. In either case, the main part of the dam would go down to bed rock. In other words, there would be no permeable strata beneath the dam, such as Senator Morgan has described, that will exist at Gatun.

Senator ANKENY. If you had to build a dam, you would build it in that way?

Mr. PARSONS. If you are going to build a dam there, it is the only way that you can build a dam, Senator.

Senator KNOX. What is the area of that restrained water of the Chagres, about?

Mr. PARSONS. Forty-three square miles.

Senator KNOX. And what is the quantity of water that would escape daily? Have you estimated that?

Mr. PARSONS. The average flow of the Chagres River at Gamboa is about 3,000 second-feet; that is the average flow per annum.

Senator KNOX. How is that carried out of the lake? Do you have sluiceways?

Mr. PARSONS. The dam at Gamboa is in two parts. There is the main dam, which will be either all masonry or with a masonry core and earth on both sides, going across the main valley. Then to the north of the valley there is a depression in the hills through which the French have already partially constructed a diversion channel. It is proposed to complete that diversion channel and to put in that depression an all-masonry structure through which the flow of the river would pass.

Senator KNOX. So that under no circumstances would there be an overflow of the dam?

Mr. PARSONS. Under no circumstances would there be an overflow of the main dam. That would be always above water, no matter whether it was built of earth or all masonry.

Senator KNOX. And of course, in order to determine whether this diversion channel is adequate to carry off the surplus water, you have estimated the area of the rainfall, and the amount of rainfall and all that sort of thing?

Mr. PARSONS. Those figures are all given in the report, sir.

Senator KNOX. You remember the disastrous flood at Johnstown?

Mr. PARSONS. Yes.

Senator KNOX. My recollection is that that dam was built upon the theory that the dam was sufficiently high and the diversion channel was of sufficient area to carry away any water falling on that watershed that the records of one hundred years showed to have fallen; and yet that dam, being partly masonry and partly earth, did overflow, and that was the cause of the accident. Now, how far back have they the records of the rainfall on the watershed that supplies the Chagres?

Mr. PARSONS. Substantially fifty years.

Senator KNOX. Can you tell me the formula, how much they have allowed for any excess of the greatest rainfall on that watershed?

Mr. PARSONS. The biggest flood of which there is any record is the so-called flood of 1879, and it is shown that this lake will take two of those floods, one right after the other, passing only the normal amount of water through the sluices. So that you could have two of those floods, one right on top of the other, and still you would not have your lake full.

But by allowing the maximum amount of water to go through the gates that we figured on, you could lower the level of the 1879 flood in the course of a very few days after the flood had stopped and bring the lake back again to normal conditions. But even if the worst should come to the worst, and you should imagine three of those floods piled one right on top of the other and the gates would not carry the water off, then you would have the masonry dam in the diversion channel drowned out and the river would simply go over the top of that.

Senator KNOX. So that under no circumstances —

Mr. PARSONS. Under no circumstances would the water go over the top of the earth dam.

Senator KNOX. But if it did, of course it would cut it out?

Mr. PARSONS. It would cut it out; yes, sir. That you can guard against, and some of the members of the majority of the board thought that in a work of this magnitude it might be well to take that additional precaution by making the main dam a masonry dam, so that if you had four or five 1879 floods, and the whole thing was drowned out, the flood could go over the top of the main dam.

Senator KNOX. I tried those cases arising out of the Johnstown flood, and my recollection is that taking greatest rainfall in one hundred years, and allowing that that would be precipitated upon 8 inches of melting snow, the diversion channel was more than twice sufficient to meet all those requirements, and yet that lake overflowed and caused all that damage.

Mr. PARSONS. The criticism could be met here absolutely by making the whole of the dam a masonry dam to the bottom. We have provided here a sufficient estimate to build an all-masonry dam if it is desired to do so.

Senator DRYDEN. Will you point out on the map about where these diversion channels run and where they empty?

Mr. PARSONS. The diversion channel I am speaking about comes right in here [indicating on map] alongside the dam and would flow directly into the line of the canal.

Senator DRYDEN. Does part of the water from that lake empty into the Pacific and part into the Atlantic?

Mr. PARSONS. The plan is arranged so that the management can let that water flow into the Pacific, if they want to. We have proposed a series of control sluices in the neighborhood of Corozal, so that during the time when the tide in the Pacific is lower than the water in the canal—that is to say, for one-half of the day—the water could be drawn from this lake southerly through the canal and through those sluices into the Rio Grande, and at other times the water would go northerly through the canal to the Atlantic.

Senator ANKENY. Is that water adequate at all times for all necessities of that canal?

Mr. PARSONS. In a sea level proposition no water is needed for the operations at all. You see there are no locks except the tidal locks.

Senator MORGAN. Take the case of a lock canal.

Mr. PARSONS. In the case of a lock canal, then they do not use the dam at Gamboa; but with the dam at Gatun, as you can see by that map, the white and the blue spaces, they make a very much larger lake inland, and use that as their storage reservoir.

Senator ANKENY. Will that be adequate at all times?

Mr. PARSONS. It will be adequate for a very large amount of traffic. The minority has shown that if at any time that fails to supply enough water, a dam can be built higher up the Chagres Valley at Alhajuela, making an additional lake on the upper Chagres, and dams can also, if desired, be put on some of the other tributaries, and so store up enough water to carry through the operation of the locks, even with enormous tennage, through the dry season.

Senator MORGAN. Take a lock canal about 10 miles in length, between Gamboa and Pedro Miguel or Miraflores, of about the same

dimensions with a sea-level canal that might run on either side of this Culebra ridge, and is there enough water in that lake impounded by the dam, as proposed by the majority, for the regulation of the Chagres River, to supply the canal in full working order between those points that I have mentioned, Gamboa and Pedro Miguel?

Mr. PARSONS. There would be, I believe, Senator, if you put your level as low as 60 feet. I think you would get enough water in the Gamboa Lake to supply enough water for lockage on a 60-foot level, at any rate until your traffic became very, very large, and by that time you would probably have your locks removed.

Senator MORGAN. If you were to build a canal between Gamboa and Pedro Miguel or Miraflores, across the Culebra heights, would you prefer 60 feet, or would you prefer 80 or 85 feet?

Mr. PARSONS. If I were to build a canal there I should figure on establishing my locks on each side of the ridge and then begin to cut, and cut that summit down just as fast as I could cut it down until I met the locks coming up; and I should figure on getting it down to at least an elevation of 60 feet, or possibly less.

Senator MORGAN. Sixty feet or less?

Mr. PARSONS. Yes.

Senator MORGAN. But you think 60 feet would be a safe calculation as to the usefulness of the canal?

Mr. PARSONS. Yes; I think you would have water enough in the Gamboa Lake to supply water for lockages on the 60-foot level for the traffic that could be passing in the immediate future.

Senator MORGAN. You would lock up to it by, say, two locks of 30 feet each, and down the same way?

Mr. PARSONS. Yes, sir.

Senator MORGAN. Is a 30-foot lock considered a dangerous elevation for a great ship canal like this?

Mr. PARSONS. Any locks are a dangerous elevation, Senator.

Senator MORGAN. But is a 30-foot lock extraordinarily dangerous?

Mr. PARSONS. No, sir.

Senator MORGAN. Not nearly so bad as a 45-foot lock?

Mr. PARSONS. No, sir. A 30-foot lock is a lock within reasonable dimensions.

Senator MORGAN. That is what I wanted to get at. That is all.

Senator ANKENY. You speak of increased traffic. What maximum did you consider for the increased traffic? What did you anticipate when you said "enough for increased traffic" or for greater traffic? That, of course, is a term I do not quite fix. What tonnage did you fix?

Mr. PARSONS. I have not fixed any tonnage. In the minority report, where they were obliged to make those calculations—

Senator ANKENY. I saw that; but, in your opinion, what tonnage should be fixed?

Mr. PARSONS. In my opinion, the figures they gave there are a very large tonnage. They were figuring, I think, that the Gatun lock would supply lockages for 50,000,000 tons per annum. I think that they have taken a little too hopeful view of the situation.

Senator ANKENY. You think that is sanguine?

Mr. PARSONS. Yes, sir; I think their figures are sanguine; but then, of course, 50,000,000 tons per annum is an enormous traffic.

Senator ANKENY. What is it in the Soo?

Mr. PARSONS. In the Soo it is 40,000,000 tons, I think.

The CHAIRMAN. You speak of the Soo. A better comparison would be to compare this Panama Canal with the Suez Canal, would it not?

Mr. PARSONS. I would rather compare it with the Suez.

Senator ANKENY. The Suez is an open sea canal, and the Soo is a lock canal. We are figuring on lock canals, and I do not think the comparison would apply.

Mr. PARSONS. So far as the question of operation is concerned; but I understood Senator Millard's question to refer more to the question of traffic.

The CHAIRMAN. Yes.

Senator ANKENY. Oh, I beg pardon.

Mr. PARSONS. It was in that point of view that I gave the answer, Senator.

Senator KITTREDGE. Yesterday, when we were about to adjourn, you were telling us about the speed of ships, and have indicated the additional time necessary to pass through the six locks. At your convenience will you give your figures for that operation?

Mr. PARSONS. The board, on page 50 of its report, stated that the dimensions adopted by the board will permit "a speed of 6 miles per hour for the largest existing vessels using it, and of not less than 8 miles per hour for the average ship." The canal is substantially 50 miles long from deep water in the Atlantic to deep water in the Pacific, of which 40 miles are between shore and shore and with a more or less restricted channel. Take the minimum figures for the average ship of 8 miles per hour—and those figures are based on the experience of the Manchester and Suez canals—and we would have 40 miles at 8 miles an hour, or five hours for the land portion of the canal; and then 10 miles at 10 miles per hour, making an hour more, so that it would take six hours for vessels to travel from ocean to ocean, exclusive of the delays in stopping to get orders, to be measured, to pay duties, and so forth, which are inseparable from any canal and of course entirely independent of type of the canal. It would take six hours of steaming time at the minimum rates, as proved, to go through the canal.

Taking a lock canal on the same basis, and again the length of 50 miles, and there are 12 miles of the restricted channel, and 38 miles of either open sea, dredging or lake navigation, where we will assume the vessel could make 10 miles an hour. We would therefore have for the lock canal 12 miles at 8 miles per hour, or an hour and a half of time consumed, and 38 miles at 10 miles per hour, or three and eight-tenths hours' time consumed. Then, as I showed you yesterday, there would be four hours—a trifle more, but I take four hours—of time lost in going through the locks; making a total time of nine and three-tenths hours in passing through the lock canal, provided, of course, there were no delays. Nine and three-tenths hours' time is slightly less than the minimum time assumed by the minority of the committee, so that that indicates that I have computed that fairly.

In regard to the question of delays, in the sea-level canal there would be a delay first in passing the tidal lock which, at the worst, the Board has estimated would take an hour. Inasmuch as half the time that lock will be open, and there will be no delay, and part of the rest of the time the tidal variation will not be at the maximum, so that the hour would be diminished, a half hour would be lost on the average ship at the tidal lock. That would seem to be a reasonable figure. That would

make, therefore, six and one-half hours in going through the sea-level canal and nine hours and, say, one-half, in going through the lock canal, or a difference of three hours in favor of the sea-level canal.

The Board has also stated—and this was written after the experience of the Manchester, Kiel, and Suez canals, and subscribed to by the men who have charge of those canals: "The width adopted for the canal will be sufficient to permit steamers to maintain a speed of 6 to 8 knots per hour and to allow two merchant steamers to pass one another on the line of the canal without stopping." So that all ordinary vessels of commerce will not have to stop in passing through the sea-level canal. They might have to slow down in passing each other. So that, if you will allow half an hour or an hour for the delays in transit passing vessels, you will have from seven to seven and one-half hours of time consumed in passing through the sea-level canal, as against nine and one-half hours in passing through the lock canal. But in the lock canal I have allowed nothing for the delays in vessels passing each other in the 12 miles of restricted channel.

Senator KNOX. Which takes you about as long as it does to get up from Sandy Hook to dock in a fog?

Mr. PARSONS. I think I have spent even more time in that operation, Senator.

Senator KITTREDGE. An advantage of at least two hours?

Mr. PARSONS. An advantage of at least two hours.

Senator KITTREDGE. In favor of the sea-level canal?

Mr. PARSONS. Yes, sir; in favor of the sea-level canal.

Senator KITTREDGE. In this connection I call your attention to the testimony of Mr. Stevens, the chief engineer of the Commission, found on page 255. I will read the question—

"Senator DRYDEN. Can you tell how long it would delay a boat of the largest character that would be likely to go through there to be lifted up and go through one of these locks?"

"Mr. STEVENS. To get through the three locks?"

"Senator DRYDEN. Yes, sir.

"Mr. STEVENS. They ought to go through in from 45 to 55 minutes."

Have you any comment to make upon that statement?

Mr. PARSONS. In saying anything which might be interpreted as a criticism of Mr. Stevens, I should like to say that I noticed in reading the testimony as it appeared, that the first time that you called him he stated that he had explained to the Board of Consulting Engineers, when it was on the isthmus in the autumn, that he had been so busy with other matters that he had given practically no thought at all to the type of the canal; and when you had him before you at your first meeting in Washington—I think you had him before you three times—he stated again that he had given but very little attention to the type of the canal, having been engaged in other matters; and that at that time he had not read the minority report, and had not studied the majority report. That, I think, appears in the testimony.

Senator KITTREDGE. Do you remember the date of that? It was January 16, was it not?

Mr. PARSONS. I think that was the date when he was first called. It is a matter of record here.

Senator KITTREDGE. It is not material. You need not stop to look it up.

Mr. PARSONS. Yes; he was first called January 16, and his second testimony, which is the time you are now referring to, was a week later, on January 23. The second time he stated that in the interval he had read the two reports twice each. So that, as I say, in making what would look like a criticism of Mr. Stevens—I am not trying to criticise—I want to preface it with this statement, that Mr. Stevens practically disclaimed responsibility for definite knowledge.

In speaking of vessels going through those locks in from forty-five to fifty-five minutes, I think that Mr. Stevens misread one of the papers in the appendix to the report, where Mr. Noble and Mr. Ripley showed that the theoretical interval between two steamers in passing through the triple locks would be fifty minutes—that is, fifty minutes after the first vessel had entered the lock it would be possible to introduce a second vessel, but the first vessel would still be in the process of being locked through. And that was the theoretical time, where everything was to work exactly right.

Working it out on the theoretical time, substantially as laid down by those gentlemen, and then making an allowance of 50 per cent, which is found in the lock canals to be about a proper allowance to make for actual practice, it would take two hours and nineteen minutes instead of forty-five to fifty-five minutes to pass a flight of three locks; and those are the times that have been practically incorporated in the estimate of the minority as to the time taken to go through the canal.

Senator KITTREDGE. On the subject of the passage of large ships through this canal, I call your attention to the statement of Mr. Stevens, found on page 268, where, in answer to a question propounded by Senator Morgan, Mr. Stevens said [reading]:

“Mr. STEVENS. My opinion is that a very large ship could never be assured of getting through a sea-level canal of the dimensions reported without grounding, unless she ran at such speeds as would practically destroy the usefulness of the canal, for this reason: That out of the 49 miles there is over 29 miles that is only 200 feet wide, and you can see from the map that it is more or less tortuous in direction. I think that this situation would be accentuated by the immense number of small streams carrying flood water directly into the canal at the depths that they would, from 30 to 150 or 160 feet. They are constantly carrying in detritus that would make shallow bars that would very soon render the navigation of such a canal impracticable for large ships, and sooner or later for all ships, unless there were a fleet of dredges kept constantly working from one end to the other to keep it open.”

Have you any criticism or comment to make upon that statement of Mr. Stevens?

Mr. PARSONS. The table which I read in answer to Senator Morgan's question a few minutes ago would seem to have bearing on that question. I do not think that Mr. Stevens had fully in mind the dimensions of the Panama Canal as compared, for instance, with the Suez Canal. When he speaks about the narrow channel, he must have overlooked the fact that the sea-level channel is 50 per cent wider than the bottom width of the Suez Canal and it is actually wider than the width of the Suez Canal plus the passing places in addition; also that it has a depth 30 per cent greater, and that its maximum curvature is 40 per cent greater than the maximum curvature of the Suez. In

other words, it is a very much larger canal, and very much less tortuous than the Suez Canal, where vessels are going backward and forward constantly, and have been doing so for a great many years.

Senator HOPKINS. What is the size of the vessels that go through the Suez Canal?

Mr. PARSONS. Of course all types of vessels go through the Suez Canal.

Senator HOPKINS. What are the largest that go through that canal?

Mr. PARSONS. The largest passenger steamer of which I have record was the *Größer Kurfürst*, with a length of 500 feet, a beam of 62.3, and a draft of over 26 feet. The British battle ship *Terrible*, with a length of 500 feet, a beam of 71 feet, and a draft of 26.4 feet has also gone through.

Senator MORGAN. Those are the largest ships that have yet passed through the Suez Canal?

Mr. PARSONS. They are the largest that I know of; yes, sir.

Senator HOPKINS. There are no streams that flow into the Suez Canal, are there?

Mr. PARSONS. I have never been through the Suez Canal. May I ask General Davis? He has been through twice.

General DAVIS. There are none.

Senator MORGAN. And a fresh-water canal from Alexandria runs in there, does it not?

Mr. PARSONS. I would rather have you ask General Davis that, Senator.

General DAVIS. Yes, sir; there is a fresh-water canal leading from the Nile to Ismailia.

Senator MORGAN. What are the dimensions of that canal?

General DAVIS. It is about 10 feet deep and about 80 feet wide. It also extends to Suez, on the Red Sea side, and by aqueduct pipes to Port Said, on the Mediterranean.

Senator MORGAN. That canal is kept full of fresh water for the supply of the population?

General DAVIS. Yes, sir; and for irrigation.

Senator KITTREDGE. I want to call your attention to Mr. Stevens's testimony, found on page 278 of the record. In answer to a question by Senator Hopkins Mr. Stevens testified:

"Mr. STEVENS. To go through the locks? I should not suppose that it would take over fifteen or twenty minutes. I understand that at the Poe lock on the St. Marys Canal they put ships through in nine minutes."

What is the fact about that?

Mr. PARSONS. I think that Mr. Stevens there, in his hurry to read the reports through, had not properly taken into account the times required. In order to pass the Poe lock, Mr. Ripley states, in his paper on that subject, that after a vessel has actually stopped, and omitting the time lost in slowing down to come to a stop, it then takes her nine minutes, on the average, to go from that stop into the lock; then three minutes to close the gates; nine minutes to fill the lock or empty it; three minutes to open the gate, and, say, five minutes to move out of the lock, making a theoretical time of twenty-nine minutes from the time the vessel is stopped until it leaves the lock.

That, again, assumes that all those operations are to be made exactly on time, without any interval of time between, and without making

any allowance for the time lost by the steamer in slowing up to come to the first stop, and of course assuming that there is nothing in her way. The probabilities are that in order to pass the Poe lock forty-five to fifty minutes will be taken, without any allowance for loss of time on account of other vessels being in the way. The board assumed that it would take an hour to pass even the tidal lock at Sosa under the worst conditions of the greatest adverse tide. I think Mr. Stevens in trying to read the report hurriedly has not weighed the time lost in passing through the locks, and possibly when he takes up this question to study it he might want to have a chance to revise his opinions.

Senator KITTREDGE. I also call your attention to Mr. Stevens's testimony found on pages 284 and 285, in which he states his preference for a lock canal; and, among other things, he says that the danger of navigation in a sea-level canal is greater than in a lock canal, and so forth. The portion I refer to is lengthy, and I shall not again put it in the record.

Mr. PARSONS. That, again, seems to be based upon Mr. Stevens's misconception of the Suez Canal; and, by the way, I should like to call attention to a typographical error, where the words "Soo Canal" appear instead of "Suez Canal."

Senator KITTREDGE. In whose testimony?

Mr. PARSONS. In Mr. Stevens's testimony.

Senator KITTREDGE. Where is that?

Mr. PARSONS. It is in the long paragraph, the fourth from the bottom, about one-third the way down, where he states: "That in the Soo Canal, which was the longest example of a canal in the world—something like 90 miles, I believe—no two ships are allowed to pass at speed." It obviously means Suez Canal.

Senator KITTREDGE. I understood that.

Mr. PARSONS. That comes back to the table I read a few moments ago, that Mr. Stevens has misconceived the dimensions of the Suez Canal. Of course, with a bottom width of 108 feet it is impossible for two boats to pass, and as the passing places are arranged one of them has to go into a passing place and stop there. With the additional widening that is now in progress with the Suez Canal it is expected to widen the canal to a width of 148 feet, approximately, all the way through—in other words, to connect the passing places—when ordinary vessels will pass each other without the necessity of tying up.

The CHAIRMAN. These large ships that are being built now could not pass in that width, could they?

Mr. PARSONS. Not at speed; no. With those very large ships now being built, or in the case of a battle ship, which steers badly, undoubtedly one vessel would have to stop; but in a case like that, where there is room enough to pass at all points, the meeting places, of course, could be very easily effected and arranged by telegraphic orders to the two ships in advance, and one vessel would stop anywhere and the other vessel would simply go by.

Senator HOPKINS. The great majority of ships that pass through the Suez Canal do not exceed 400 feet in length, do they?

Mr. PARSONS. No. That is, the ordinary ships of commerce are not these very large ships.

Senator HOPKINS. And the depth of the Suez Canal is not sufficient to permit vessels of the largest type to pass?

Mr. PARSONS. No; the very large vessels can not go through. They are deepening the canal now so as to permit it.

Senator MORGAN. The Suez Canal is 99 miles long, is it not—not 90 miles?

Mr. PARSONS. I was reading from Mr. Stevens's testimony.

Senator MORGAN. He was mistaken in the length of it by 9 miles, then. As I understand it, it is 99 miles long.

Senator HOPKINS. That Suez Canal passes through a perfectly level country, does it not?

Mr. PARSONS. It does.

Senator HOPKINS. Of a sandy soil?

Mr. PARSONS. Of a sandy soil. There are some rock and some hard material.

Senator MORGAN. There is a good deal of marl, is there not?

Mr. PARSONS. That is what I meant by hard material.

Senator HOPKINS. Has the Suez Canal any lock at all?

Mr. PARSONS. No, sir.

Senator HOPKINS. None whatever?

Mr. PARSONS. No.

Senator MORGAN. I thought it had a tide lock on the Mediterranean, but Mr. Parsons says it has not.

I would like to draw Mr. Parsons's attention to another matter. Taking the floor of the canal to be 40 feet below mean sea level all the way across the Isthmus, you would encounter rock at Gamboa, and you would continue to encounter it until you got to Pedro Miguel, digging the canal at that depth below sea level?

Mr. PARSONS. Yes, sir.

Senator MORGAN. About what would be the average height, if you can come at the computation in any way, of that mass of rock above sea level through that extent? Would it be 10 feet thick, or 5 feet, or 20 feet, or what?

Mr. PARSONS. Between Gamboa and Pedro Miguel?

Senator MORGAN. Yes.

Mr. PARSONS. I think I can get it from the profile here, sir. [Referring to map.] The rock or rocky material, I suppose, would average between those points 100 or 125 feet.

Senator MORGAN. In depth?

Mr. PARSONS. Yes, sir.

Senator MORGAN. So that that much of rock material would have to be removed before you would get to the floor of the canal?

Mr. PARSONS. Yes, sir; possibly to the floor of the canal it might even be somewhat more than that. In the greater part of that distance, through the Culebra cut, the surface of the ground now is, in round numbers, from 140 to 150 feet above mean sea level, and that would be 180 feet above the bottom of the canal. That is nearly all in either rock or rocky material.

Senator MORGAN. About what would be the length in miles of this cut through this rock?

Mr. PARSONS. Between Obispo and Pedro Miguel is 8 miles, in round numbers.

Senator MORGAN. So that there would be 8 miles of rock to be removed, one hundred and how many feet thick, did you say?

Mr. PARSONS. On an average, say, 125 feet.

Senator MORGAN. Well, that is in the main tough, hard rock—basalt, is it not?

Mr. PARSONS. It is basalt or a very, very hard clay that amounts almost to a rock. It is very variable in quality, but it is either rock or rocky material. It all requires blasting.

Senator MORGAN. I wish to ask you whether the joint board of engineers, in their study of this sea-level route, took into consideration its liability to convulsions from volcanoes or earthquakes?

Mr. PARSONS. We did.

Senator MORGAN. You took it into consideration?

Mr. PARSONS. We did.

Senator MORGAN. Did you notice the report that was made by Admiral Walker and his Commission, called the "Nicaragua Canal Commission," in 1899, in which they say:

"For Panama the records show 28 earthquakes. Of these, 12 occurred in the three years 1882, 1883, and 1884, which illustrates the incompleteness of the record as a whole. The only one that could be called destructive was that of 1621, which destroyed nearly all the houses in Panama. The next most severe was that of September 7, 1882. During this earthquake a part of the front of the cathedral in Panama was thrown down and the headquarters building of the canal company was cracked; the railroad had its track and roadbed in places thrown out of line, and the masonry of three or four bridges and culverts was damaged; at Las Cruces the church was thrown down; at Colon some lives were lost and crevasses were opened, and the Jamaica telegraph cable was broken."

That is a statement of that Commission.

The report was made in the daily Star and Herald of September 8, 1882, as follows:

[Star and Herald, September 14, 1882.]

SEVERE EARTHQUAKE ON THE ISTHMUS—MUCH DAMAGE DONE.

During the past week the Isthmus has been visited by several earthquakes which have done damage, but which fortunately have only caused two deaths. The following, copied from the daily Star and Herald, describes the events as they occurred from day to day:

[Daily Star and Herald, September 8.]

On Thursday, 7th instant, at 3.20 in the morning, the inhabitants of Panama were aroused from their beds by one of the longest and most severe earthquake shocks which has ever been experienced in this city. It was preceded by a hollow, rumbling noise which aroused and alarmed many persons. The motion was wave-like, and proceeded almost directly from north to south. The first and most severe shock must have lasted at least thirty seconds. Commencing with a moderate movement, it deepened in intensity, and toward the finish was so violent in strength that had it lasted ten seconds longer it is probable that at this moment there would not be a house standing in Panama. The shock had hardly terminated when the streets were filled with people, many of whom sought the outskirts of the town in order to avoid danger from the fall of edifices. A second and milder shock occurred about half an hour after the first one.

It is almost impossible to deplet the alarm and excitement which followed. Panama has always been considered exempt from the mighty natural convulsions which are experienced almost periodically in the countries through which the giant Cordillera stretches its mountainous and volcanic ridges. That the shocks this morning were of exceptional violence appears to indicate a terrible calamity in some of those districts—and in all probability in the north—rather than a possibility that the old-time freedom of the Isthmus from earthquakes is

about to disappear, and that henceforth we are to be subject to such dangerous and fearful visitations as those which on that morning threatened the city with ruin.

The amount of damage done can not as yet be estimated, but it must amount to at least \$250,000. The municipal building and assembly rooms, under which the Cascada is situated, were much damaged. The whole of the massive balcony fell bodily into the square, dragging with it the roof and all adjacent timber.

The cathedral also suffered severely. Almost the whole of the ornate pediment, composed of heavy blocks of masonry, fell through the roof or onto the steps leading to the principal entrance. Every arch in the nave is cracked and split, and large stones and pieces of cement have fallen from them. The side aisles are also seriously damaged, and an expenditure of at least \$50,000 will be required to restore the building. The roof of the assembly room will be repaired at an early date, Governor Borbua having acted with remarkable celerity and commenced work at once in order that the archives and furniture may not be exposed to damage from the rain.

Private houses damaged are innumerable, and owners as yet fail to form a correct idea of the losses they have incurred. The walls of the canal office are cracked in several places, and the edifice requires strengthening. No estimate of damage can be made, but an expenditure of several thousand dollars must be incurred to render the building as safe as it was before the shock.

The ruins of buildings destroyed by fire are unfortunately too conspicuous in the center of the city. Their danger has frequently been pointed out, and the earthquake has now accentuated the peril consequent on their being allowed to remain as heretofore. Masses of these ruins have fallen down, and gaping cracks prove the necessity that they should be torn down. Outside the city a number of houses have suffered. The tower of Malambo Church has fallen, and a piece several yards square of the roof of Santa Ana Church has tumbled in. The crash among glassware and bottles has been universal, Mr. Brakemeier alone being a loser to the extent of \$2,000 from this cause. General Alzupuru's house, in the Calle Real, has suffered severely, as has also that of Don Manuel Hurtado, in front of the Government house. Others who have suffered damage are Señores Antonio Jimenez, Agustin Clement, José Manuel Casis, Barsallo, and the Grand Hotel, but the full extent of the damage done will not be known until the investigating committee has concluded its labors.

Several hours have now elapsed and there has been no repetition of the shocks. It may therefore be confidently anticipated that they will not be repeated.

The Pacific Mail steamship *Clyde* arrived from San Francisco on the night of the 6th. The earthquake was severely felt on board. Passengers declared that it appeared as if the vessel were lifted bodily from the sea and allowed to fall back.

Thanks to the kindness of Mr. J. B. Stearns, general manager of the Central and South American Cable Company, we are able to inform our readers that the offices at Buenaventura, in Cauca, and San Juan del Sur, in Nicaragua, announce that no shock has been felt in either of those ports. The cable is working excellently and gives no sign that a general volcanic disturbance has taken place.

The effects of the earthquake along the railroad have been most marked. The stone abutments of several of the bridges have been cracked and split and the earthwork has sunk in a half a dozen places. Gangs of men were put at work on Thursday so that traffic might be resumed as usual at the earliest possible day. Mr. Woods and his subordinates have been active and energetic as usual, and cars were busily employed loading ballast to fill the sunken places, while lumber was being cut and prepared to support the short bridges which have been weakened, as already mentioned, through the cracking of the abutments.

All along the railroad track the earthquake was severely felt. At Emperador, Gatun, Matáchin, and all the canal stations much alarm was created.

In several places where the direct action of the shock appears to have made itself most strongly felt the rails were curved as if they had been intentionally bent.

Mr. Woods, general superintendent of the railway, went across the same morning and returned as far as Ballamona in the afternoon. Neither train crossed in the afternoon. The Panama train stopped on this side of Ballu-

mona bridge and the passengers and their baggage were transferred to hand and push cars, and thus conveyed 8 miles over the road to Bohio Soldado—the farthest point the train from Colon could reach.

The earthquake created great alarm in Colon. The freight house was damaged, and it was rumored that one or two were killed, but no certain information on this point has been obtainable. It is known, however, that two gentlemen broke their legs through jumping from the upper stories of houses.

The telegraph wire was down during the early part of the day, but communication was reestablished at about 4 p. m.

The sea was remarkably calm at Colon at the time of the severe shock, thus tending to prove that the earth motion has not extended, as at first supposed, to the West Indies.

The passengers and mails per Royal Mail steamer *Don* could not come across yesterday, so that the *Lima*, after being delayed a day, had to leave for the south without them.

[Daily Star and Herald, September 8.]

• Mother Earth on the Isthmus has not as yet returned to her ordinary quiescent condition. The severe shock of the morning of the 7th has been followed by several of less intensity, but which do not appear to make their effects felt over such a wide area. On Thursday afternoon several vibrations were experienced in different localities which were not felt in Panama.

At 11.30 p. m. on the 7th a sharp shock alarmed the whole city and drove the people from their houses to the squares. Hundreds of ladies, accustomed to every convenience and comfort, preferred to pass the night on mattresses, couches, and chairs in the public plazas to running the risk of being crushed to death in the houses. The inconveniences of the situation they thus accepted were obvious to the less timid, who walked from one square to another to see these temporary and uncampaign-like encampments.

A slighter shock occurred at about 3 in the morning, but fortunately neither it nor its predecessor added further ruin to that already incurred in the city.

All the shocks have been felt on the islands in the bay and some houses have suffered at Taboga.

La Chorrera has been very unfortunate. The church and the cemetery are a mass of ruins, and a number of houses have fallen. A bakery took fire and it and the adjoining house were totally destroyed by fire.

Between Gavilan and Punta Mala, in the vicinity of this city, a crevasse has opened which is 10 meters in width.

Some of the ruinous walls are being taken down, but there are several yet standing which are a permanent menace to adjoining properties and the lives of their inhabitants.

[Colon correspondence Daily Star and Herald, September 9.]

On the morning of September 7, at about 3.15, the residents of Colon were aroused from their peaceful slumber by the earthquake shock which has caused so much alarm and so considerable damage to the whole Isthmus. The duration of the shock was fully sixty seconds and was so severe that the whole populace rushed from their domiciles into the streets as their feet could carry them.

The greatest alarm prevailed. About half an hour afterwards another shock was felt, but much lighter than the first. The sensation produced by the first and more violent shock was that the whole town was about to sink into the bowels of the earth. No very considerable damage was done. Several buildings were more or less damaged, including the French consulate, the house of Mr. F. R. Cowan, the Panama Railroad freight houses, and the wharves, the International Hotel, some smaller tenements in the rear of the town in the alley known as Cash street. One of the latter, built of brick and wood in the style known as brick noggin, was wrecked completely, and one unfortunate occupant, a native, was killed. Two others, one a Frenchman and the other a bookkeeper for Messrs. Isaacs & Asch, had each a leg broken in their haste to escape. The former will have to submit to the painful operation of amputation.

A deep fissure was opened in the earth from the south end of the freight house for a distance of about 400 feet along the walk leading in the direction of the

ice houses. Many buildings were moved slightly from their foundations, but on the whole remarkably little damage was done. On board the vessels in the harbor the shock was also felt very severely.

The losses sustained were principally in the breakage of bottles in the various stores and shops, and the smashing of crockery, mirrors, etc., in private residences. This is pronounced the most severe shaking up ever before experienced in the history of the country since the discovery and conquest, but on the whole the town has escaped without serious injury. On the 7th instant, about 1 p. m., another much slighter shock was felt, and during the night of the same day two more slight disturbances were reported. The people of the town have become quite alarmed and quite demoralized by these events, many rushing to the churches and calling upon God for protection and deliverance. If the result proves beneficial to the moral tone of the city, the tonic, although severe, may not be regretted.

It may be of meteorological interest to observe that the sea at the time remained here calm, the atmosphere quite clear, and the stars and waning moon remarkably brilliant. Soon after, say about 4 o'clock, a slight fog wafted from inland. No rain fell. All day an ominous calm prevailed, without rain, with fluctuating barometer and excessive heat, which led many to fear a return of the shocks during the night of the 7th, and few slept. But with the slight exceptions noted all remained quiet.

Another correspondent writes from Colon:

"At about 10 minutes past 3 this morning we experienced the most horrible earthquake that I ever felt in my life. The damage done I can not estimate. A German employed as bookkeeper by Messrs. Isaacs & Asch threw himself out of the window and broke his leg, and a colored man followed his example, with a similar result. Two men have been killed, one of them being buried under a falling roof. The whole of the made ground between the wharves and the lagoon is split in a number of places.

"A number of houses have suffered severely. Some have fallen down bodily. Number four mole and the freight house has been damaged. All here think the motion lasted at least one minute, and that it moved from the southeast toward the northwest."

[Daily Star and Herald, September 11.]

A slight earthquake shock occurred on the morning of the 9th a little before 5 o'clock. Much alarm was naturally created, but fortunately no damage was done. The frequent repetition of these movements causes a painful and uneasy feeling among the populace. A number of families passed the night on board the vessels in the bay and many in the public squares, and on Saturday a great many occupied the light cane houses on the outskirts of the city and at the Savana.

The same shock was lightly felt in Colon and along the railroad track. No damage was done, and work was continued on the houses injured by the shock of the 7th instant.

All day on Saturday no shock was felt, and the night passed quietly. At midday on Saturday there was a marked change in the atmosphere, and, with a refreshing shower which fell, the murky, sultry air of the previous days entirely disappeared.

The rumor of a volcanic eruption at the town and fort of Chagres is pronounced entirely false. Thoroughly reliable persons were there at 1 p. m. on Saturday and reached Colon the same evening. They report the earthquake to have been felt there, and that the earth had cracked slightly in two or three places. Beyond this no damage was done.

The shocks have been lightly felt on board the vessels in the bay, but they have experienced absolutely none of the tidal-wave effects which so frequently accompany widespread and powerful convulsions.

Passenger and freight trains will run over the road to-day as usual, as it is believed all the breaks will have been thoroughly repaired last evening.

The earthquake destroyed the little church at Cruces and damaged a few houses.

The rumors of a volcanic eruption at Chagres are entirely without foundation. The earthquake was felt there, did some little damage, and opened a few cracks in the ground.

A cablegram received from Mr. Scrymser, the president of the Central American Cable Company, announces that in New York it was known the Colon cable was broken and that nothing had occurred in Cuba and the other islands.

[Daily Star and Herald, September 12.]

A commission of canal employees left Panama on Sunday afternoon and proceeded to Chagres to inspect the ground where the volcanic eruption is said to have taken place. A photographer accompanies them in order to obtain exact representations of any physical changes which may have occurred. The principal members of it are MM. Canel, Alvo, and Canell. It is believed they will be absent about a fortnight, as they have to examine a wide field.

The rumors of the volcanic eruptions near Chagres and Cruces are declared to be entirely false by people arrived from there. One or two persons declare, however, that at 20 miles from Chagres, in the direction of "the coast," a small mud volcano has been observed, but these statements are as untrustworthy and false as many which have been set current within the past few days.

The truth of the matter appears to be that the repeated shocks have settled the loose alluvial soil, and that subsidence has occurred in several places, leaving fissures in some and in others ejecting the thin mud formed on the lower strata by the percolation of water. All the fissures observed so far present the same characteristics and appear to be formed in the manner described and not by volcanic rents originating in the bowels of the earth.

The bridges on the railroad are now fully restored and freight and passenger trains crossed as usual yesterday.

More rain is falling at Colon and on the other side of the Isthmus than on the Panama side.

Three old and valueless ranches fell at Gatun when the severe shock of the 7th took place. A beam from one of them struck and instantly killed a poor woman, who was asleep.

A number of people have walked, ridden, and canoed through the center of the Isthmus in order to discover the supposed volcanic center. Their labor has been valueless, and all have returned convinced that no excessively severe motion has been experienced in any part. No loss of life has occurred save the three cases we have reported.

[Daily Star and Herald, September 13.]

The earthquake of the 7th instant was felt at the Pearl Islands in the bay. At San Miguel one of the walls of the church fell in, and the inhabitants took the saints out and carried them in procession in the hope of preventing the repetition of the convulsion. They were panic-stricken. A correspondent writes that the earth continued moving for five minutes, but this must be incorrect.

At Donoso, Govea, and Rio Indio a number of shocks have been felt, and the people have been much frightened. At Miguel la Borda, 35 miles from Colon, in the direction of Bocas del Toro, the tide rose to an unusual height and flooded some of the houses, which are built on the beach almost on a level with the sea. The earth is said to have sunk in about a dozen places, and that cattle have been lost from this cause. The governor of the district writes officially that several boiling springs have suddenly appeared, some of which throw hot water to a considerable height. Although official, this report lacks confirmation.

Many people believe they felt shocks in Panama during the night of the 11th instant, but the majority declare no movement took place. Overexcitement in many cases conduces the belief that the earth is trembling, and the least sound, such as a heavy cart passing through the streets, is at once converted by the excitable into the commencement of a catastrophe.

A number of houses in Colon have suffered. A list is being drawn up. The heavy stone offices of the canal company have been badly cracked, and the employees are removing the desks, etc., to another building. The International Hotel, one of the largest buildings in Colon, has been somewhat damaged, but the trivial nature of the injury in such an extensive edifice seems to prove that

good brickwork can resist movements which seriously injure houses which have been cheaply constructed. The moles in front of the freight house and the made ground at the back of it show signs of the movement, but the heavy stone walls of the building, although cracked in some places, are sound and good, while the iron trestlework which sustains the roof and holds the walls together is as tight and plumb as the day it was put together. Many frame houses have sagged over in different directions. The majority of these houses were never remarkable for symmetry; now they zigzag one way and the other and give the town a most peculiar appearance. It must be remembered there are a number of frame buildings in Colon which were run up as the earth was dumped into the sea to form the spit on which the town stands, and that consequently it is not surprising if the slightest shake should affect these frail wooden structures which have been exposed during nearly thirty years to the vicissitudes of the variable tropical climate.

The bronze statue of Christopher Columbus was shaken free from the stone pedestal on which it stands, and moved about 4 inches from its former location. It can be readjusted at slight cost.

At 6 a. m. yesterday the rain was pouring down in torrents in Colon.

The Harrison steamer *Mediator* has arrived at Colon, and reports that a slight shock of earthquake was felt in Cartagena on the morning of the 7th. No damage was done. Letters from there dated the 9th scarcely mention the occurrence, thus proving the little importance attached to it.

Letters have been received from the towns of La Villa, Chitre, Macaracas, and Nata, all in this State, announcing that several shocks have been felt, but that the material of which the houses are built—bamboos and adobes—resisted the movements and have suffered no damage. At La Villa the bells in the church rang several times. The people do not appear to have been so alarmed as they have been in other parts of the Isthmus.

[Daily Star and Herald, September 14.]

Messrs. Schuber Brothers' steamer *Cargador*, from ports in the northern Departments of the State of Panama, arrived yesterday, reports that repeated earthquakes have been felt, but that no damage to life or property has followed.

The canal Commissioners sent to examine reported volcanic effects in the center of the Isthmus have telegraphed that they are unable to find traces proving that the shocks have been sharper there than anywhere else in the State.

Two or three slight tremblings were experienced in this city during the night of the 12th, but they caused no alarm. Many people are returning to their houses.

I wanted to call your attention to that situation and to ask you whether the taking out of 165 feet of rock for a distance of 10 miles through the Culebra Heights, if it had occurred before that earthquake took place, would not, in your judgment, have produced very serious consequences?

Mr. PARSONS. I think not, Senator.

Senator MORGAN. You say not?

Mr. PARSONS. I think not.

Senator MORGAN. Is it your opinion that the deeper you go into the earth across that Isthmus the greater the security is against earthquakes?

Mr. PARSONS. No, sir.

Senator MORGAN. Do you not think that that uplift of land called "Culebra Ridge," underlaid by this strata of basaltic rock, is stronger to resist earthquake motion than it will be when you have dug it out to 40 feet below sea level?

Mr. PARSONS. I do not believe that the depth of that excavation would have any effect, one way or the other.

Senator MORGAN. You think not?

Mr. PARSONS. I think not, sir.

Senator MORGAN. Within a reasonable period, as late as the 31st of January, 1906, an earthquake has occurred on the coast below Panama, not distant more than 200 or 250 miles, I think, which entered a bay on the Pacific side of Ecuador and passed through to Cartagena, which is on the Madeira River, in the State of Colombia, and that earthquake broke the cables in four places, and, as the papers state, tore down villages situated on this bay that I speak of; and its effects were also transmitted through to Cartagena to such an extent that a cable in that vicinity—I do not know exactly where it is located—was also broken. That indicates that there is a repetition of this volcano or earthquake action still going on.

Mr. PARSONS. Oh, yes; we have earthquakes all over the world. We have them here and in New York—everywhere.

Senator MORGAN. Do you think that a lock canal across the Isthmus of Panama would be no safer than a sea-level canal under those conditions?

Mr. PARSONS. I do not think it would be as safe.

Senator MORGAN. Will you state a reason for that?

Mr. PARSONS. I think that the danger to be feared from earthquakes is in connection with the locks—in throwing the gates out of adjustment, so that you could not work them.

Senator MORGAN. That would be an additional danger?

Mr. PARSONS. I think so. I consider that the greatest danger from earthquakes would be felt at the locks. I should not be so much afraid of an earthquake in an open excavation. You might have, undoubtedly would have, rock thrown off from the side; and if the rock came down upon and struck a passing ship you would have an accident.

Senator MORGAN. All of the witnesses here have described bits of what they call slipping or creeping clay that are found in this great elevation at the greatest depth of the Culebra cut that, in times of great rainfall, come out of their location and fall upon the benches, and so forth, and some of them have fallen down upon the diggings and covered up, as they state, tracks and cars and the like of that. Now, if you take out the stone to a depth of 40 feet below sea level through the Culebra cut, would it or would it not greatly increase the danger of the filling up of the canal by these landslides?

Mr. PARSONS. The clay is found at the extreme summit of Culebra cut, and the great bulk of that clay will be removed in the ordinary construction of the canal. Mr. Stevens himself, in his testimony, has gone into that with very great thoroughness. I noticed that when I read over his testimony. And I think he showed that the biggest slide that they have had there includes only some 200,000 or 225,000 cubic yards, if I remember the figures correctly; so that even that big slide is of no great amount, and that, he explained, is being caused by the water getting into the top and sliding that clay off.

Senator MORGAN. The main point that I want to get at is this: Whether or not this consulting board regarded the fact that such an earthquake as I have read about here occurred in 1882, and that there were a number of instances before mentioned in the report of Admiral Walker; whether that board disregarded or ignored the possible effect of the recurrence of these earthquake movements in

considering both types of the canal; whether they disregarded it as an element not worthy of consideration?

Mr. PARSONS. Oh, no; the possibility of earthquakes was taken into account. It was one of the reasons of the majority, and it was one of my own reasons for preferring the sea-level canal. I consider that there is very much less danger of damage to a sea-level canal by earthquakes than there would be with a lock canal. The locks are necessarily more or less delicate structures. The gates have to close exactly; they are very heavy, weighing hundreds of tons, and there is also the machinery to operate them. With a very violent earthquake if the foundations of that lock were disturbed the gates would not operate and you would have to take the gates down and reconstruct them. It might even be that the gates would be so thrown out as to leak and drain off the water from that upper level.

Senator MORGAN. So that you consider a sea-level canal safer against earthquake movements than a lock canal through that portion?

Mr. PARSONS. Very much more so.

Senator MORGAN. But that a lock canal can be constructed with locks at Gamboa, which is practically outside of this rock belt, and locks at Pedro Miguel and Miraflores, which is practically outside also, in the other direction?

Mr. PARSONS. Yes.

Senator MORGAN. So that locks constructed at those places would not be, as you think, so amenable to earthquake disturbance?

Mr. PARSONS. Oh, no; I think you run the risk of earthquake disturbance all the way across. I would rather have no locks at all; but, as we were discussing yesterday, if you are going to put in a canal that can be transformed into a sea-level canal, the best way is to put in locks on the north and south flanks of the divide, and then remove them subsequently, after the beginning of the operation of the canal.

Senator KITTREDGE. What would be the distance between a lock at Obispo and at Pedro Miguel?

Mr. PARSONS. About 8 miles.

The CHAIRMAN. If no other Senators desire to ask any questions we will excuse you, Mr. Parsons, and we are very much obliged to you. The committee will have no meeting this afternoon, but will adjourn until half past 10 to-morrow.

(The committee thereupon adjourned until to-morrow, March 15, 1906, at 10.30 o'clock a. m.)

STATEMENT OF ALFRED NOBLE
BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Thursday, March 15, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Hopkins, Knox, Ankeny, Morgan, Taliaferro, and Simmons.

Present also, Maj. Gen. George W. Davis, U. S. Army (retired).

STATEMENT OF ALFRED NOBLE, ESQ.

The CHAIRMAN. Mr. Noble, kindly state your name and address to the stenographer.

Mr. NOBLE. Alfred Noble; No. 1 West Thirty-fourth street, New York.

Senator KITTREDGE. What is your age, Mr. Noble?

Mr. NOBLE. Sixty-one.

Senator KITTREDGE. And what is your professional record and experience?

Mr. NOBLE. I was graduated from the engineering department of Michigan University in 1870. For about two years preceding I had been, the larger part of the time, on harbor works in Lake Michigan, and shortly after graduation I went to the St. Marys Falls Canal, where I remained in local charge for twelve years. I was then engaged in bridge work at various localities. Do you wish the details of that, Senator?

Senator KITTREDGE. Oh, no; just in a general way, to indicate the experience that you have had as an engineer; that is all.

Mr. NOBLE. I was engaged on bridge work as resident engineer and assistant chief engineer until 1894, and since that time I have been in general practice, or, rather, I was in general practice for several years, during which time I was a member of the Nicaragua Canal Board and of the Board of Engineers on Deep Waterways.

Senator KITTREDGE. With what great engineering work are you now connected?

Mr. NOBLE. I am now chief engineer of a portion of the Pennsylvania Railroad terminal proposition in New York.

Senator KITTREDGE. You were connected with what is called the Ludlow Commission?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. When was that created, and how long did you serve as a member of it?

Mr. NOBLE. That was created in the spring of 1895, and we finished our work, I think, October 31 of the same year.

Senator KITTREDGE. You were also a member of what is known as the Walker Commission, or the Isthmian Canal Commission appointed in 1899, were you not?

Mr. NOBLE. Yes, sir; I was a member of the first Isthmian Canal Commission.

Senator KITTREDGE. And continued in that service for what length of time?

Mr. NOBLE. Our work was practically finished in 1901. We were disbanded about two years later, I think.

Senator KITTREDGE. During the past year you were a member of the Board of Consulting Engineers of the Panama Canal?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. You served in that capacity?

Mr. NOBLE. I served in that capacity; yes, sir.

Senator KITTREDGE. Signing the minority report?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. Which we have before us. Of course you are familiar with the majority report of that Board?

Mr. NOBLE. I am.

Senator KITTREDGE. Have you any criticism to make of the views of the majority further than you have expressed in the minority report which you signed?

Mr. NOBLE. I do not think that I have, Senator.

Senator HOPKINS. Mr. Noble, if there is any reason why we can not have a sea-level canal there, I would like you to go on and show why, in your judgment, that is not a good canal to construct.

Mr. NOBLE. I think, Senator, that the comparison of any two projects which capable engineers would devise for the isthmian canal must be a comparison of relative advantages and disadvantages. Each type of canal has its features of superiority and its features of inferiority.

Senator HOPKINS. What are the features of inferiority in the sea-level canal now?

Mr. NOBLE. The principal one is the contracted waterway as compared with a lock canal, and its greater cost.

Senator HOPKINS. What disadvantages are there in a contracted waterway?

Mr. NOBLE. Slower speed of vessels and greater risk to vessels traversing the waterway.

Senator HOPKINS. Have you read the testimony of Mr. Parsons, the engineer who was last here before us?

Mr. NOBLE. No, sir; I did not receive it in time to do so.

Senator HOPKINS. Mr. Parsons, if I remember his evidence correctly, demonstrated that the sea-level canal permitted a quicker passage than the canal proposed by the minority by some three hours, if I remember.

Senator KITTREDGE. At least two hours.

Senator HOPKINS. Yes; at least two hours. What have you to say to that?

Mr. NOBLE. I think that the time required to pass through the Isthmian Canal must be taken in connection with the volume of the traffic. I have no doubt whatever that a small vessel, meeting no others, could pass through the sea-level canal in less time than through the lock canal. I do not think that a vessel of the largest

size that is now contemplated could do so, and when the traffic gets very dense I do not think that any of them could do so.

Senator HOPKINS. Well, why? Why do you make that statement? Make it clear by a detailed statement.

Mr. NOBLE. I think it is pretty generally agreed by all members of the Board, practically, that if two vessels of moderate size, or larger, were to meet in the sea-level canal, one of them would have to tie up while the other passed. That is the practice at Suez, and it is expected to be the case there, even after they get their widening completed. That is the case at Manchester; it is the case at Kiel.

At those meeting places it is necessary to have a force of men to take lines and to assist in making the vessels fast, to have mooring piles driven, and a regular place for it, so that the amount of delay that would occur in consequence of those meetings would depend upon the number and distance between those meeting places. In the report of the minority is given the result of a calculation, made as carefully as we could make it, of the length of time required by two different types of ships, with two different arrangements of meeting places. A comparison of those will show what effect the distance between mooring places has.

At Suez the distance between the mooring places appears to be about 4 miles. These calculations in the minority report are based one on an interval of about 5 miles and the other on intervals of $2\frac{1}{2}$. Those delays would be cumulative in case of a heavy traffic and would very soon, as traffic increased, make it require a longer time for ships to pass the sea-level canal than to pass the lock canal.

I do not see any escape from that conclusion.

Senator HOPKINS. Then you think that, while theoretically the friends of a sea-level canal can figure out two hours of time saved over the lock canal, that as a practical matter the result will be just the reverse?

Mr. NOBLE. When the traffic becomes somewhat dense.

Senator TALIAFERRO. Mr. Noble, is it a fact or not that the capacity of the lock canal is measured by the capacity of the narrowest point in the lock canal, or the locks themselves?

Mr. NOBLE. I think that is true, without a doubt. The waterway in the lock canal is so broad that there will be no difficulty in vessels passing anywhere, excepting possibly in a distance of less than 5 miles through the narrowest portion of the Culebra cut.

Senator TALIAFERRO. But if you were measuring the greatest capacity of the lock canal, would that maximum capacity be limited by the capacity of the locks in your lock canal?

Mr. NOBLE. I think so, Senator.

Senator HOPKINS. Before we get through with the sea-level canal I want to ask you if any fair comparison can be made between the Suez Canal and the proposed sea-level canal at the point proposed by the American Government here at Panama?

Mr. NOBLE. I think the conditions of navigation through the two canals will be very much the same, except as modified by the tide-lock at the Pacific end of the sea-level Panama Canal.

Senator HOPKINS. One of the engineers who has testified on this subject raised the point of objection against a sea-level canal that owing to the topography of the country here and the Chagres and

other rivers it would require constant dredging to keep the sea-level canal clear. What is your judgment about that?

Mr. NOBLE. I think that is true. I think it will require dredging to keep the sea-level canal clear, and it does to keep the Suez Canal clear. I think the parallel still holds.

Senator HOPKINS. It does?

Mr. NOBLE. Yes, sir.

Senator HOPKINS. In the case of the Suez Canal there are no streams running into that canal, are there?

Mr. NOBLE. No, sir.

Senator HOPKINS. The dredging that is required there comes from the sea, does it, from either end of the canal, or how does it come?

Mr. NOBLE. I have never been at the Suez Canal, so that any statement that I may make is based upon the best information I can get, from reading and from hearing, from those who know of it. A great deal of sand is swept into the Suez Canal from the dry desert, and a large part of the maintenance, as I understand it, is caused by that. So far as I know, the entire amount of maintenance, as they classify it, at the Suez Canal is caused by that.

May I add a sentence to that?

Senator HOPKINS. Certainly.

Mr. NOBLE. This relates to the canal itself as a channel. At the Mediterranean end, at Port Said, there is a large amount of maintenance required to keep the entrance channel open. I am unable to say how the cost of maintenance should be divided between those two works—one to keep the canal open, the other to keep the entrance open.

Senator HOPKINS. The canal at Panama is to be cut through a very uneven country, is it not?

Mr. NOBLE. Yes, sir.

Senator HOPKINS. And the water that comes from the Chagres and other rivers must be cared for?

Mr. NOBLE. Yes, sir.

Senator HOPKINS. What is your judgment as to the effect the waters from those rivers will have upon the sea-level canal at this point?

Mr. NOBLE. I think that the silt brought down the Chagres River as far as Gamboa is adequately provided for in the project for the sea-level canal. Between Gamboa and Bohio there is an area, estimated at 250 square miles, which would drain naturally directly into the canal. A portion of that, which is, as nearly as I can measure it on the map, about 75 square miles—it may be more or less—is to be diverted by the sea-level project and passed through the dividing ridge to the eastward without entering the canal. The drainage of the remaining area, 150 square miles or more, will still flow into the canal and from a rather rapid watershed. By making catch-basins at the mouths of those streams they can catch and retain the coarser part of the material brought down, without doubt. Still, I think a good deal of the finer material would be swept into the sea-level canal and would require pretty steady attention in the way of dredging.

Senator KITTREDGE. Is there anything difficult in that operation?

Mr. NOBLE. Oh, it is nothing difficult. It is the ordinary operation of dredging, involving whatever expense is attached.

Senator HOPKINS. That would have to be constant, would it, in your judgment?

Mr. NOBLE. I think so, sir. I think it will be necessary to maintain a regular plant for that purpose.

Senator HOPKINS. For dredging purposes?

Mr. NOBLE. For dredging purposes; yes, sir.

Senator HOPKINS. And keep it constantly in operation?

Mr. NOBLE. Practically so.

Senator DRYDEN. A large and expensive plant?

Mr. NOBLE. It is pretty difficult to form an opinion as to that, Senator. The Isthmian Canal Commission, when attacking the same problem, made an estimate of the cost of maintenance and of operation, the cost of maintenance being based, as far as the maintenance of the channel is concerned, upon an assumed plant supposed to be adequate to do it, and the dredging plant in that project was to comprise two first-class dredges. In the estimates for maintenance and operation of the sea-level canal prepared for the minority report in this case we estimated that that plant would be doubled.

Senator KITTREDGE. Point out on the map the location of the rivers that are not provided for by the majority in the matter of carrying silt to the canal basin.

Mr. NOBLE. May I show instead what rivers are provided for?

Senator KITTREDGE. I would like to have you do both.

Mr. NOBLE. The entire area there that is tributary to the canal or to the Chagres between Gamboa and Gatun is given in all the estimates as 250 square miles. Now, approximately this area is provided for by a diversion of its water supply through the ridge to the outlets east of the Bohio ridge.

Senator KITTREDGE. You mean west of the Bohio ridge, do you not?

Mr. NOBLE. North of the Bohio ridge, I should say, perhaps, Senator.

Senator KITTREDGE. That is probably more accurate.

Mr. NOBLE. Yes. Now, this area measures about 73 square miles, as I drew the line on the map around these tributaries. There must be, of course, some uncertainty about that, because, as you can see, the topography is not sufficiently developed there to make that very certain.

Senator KITTREDGE. I understand that you think that has been taken care of sufficiently by the majority?

Mr. NOBLE. It looks so; yes, sir.

Senator HOPKINS. For the coarse matter; but has it for the fine?

Mr. NOBLE. All the water, as I understand it, will be retained by these dams. No water will pass down these streams below these dams, but it will find an outlet over the ridge to the northward. Consequently that is adequately provided for, I should say, as to fine material and coarse. It is conceivable—

Senator KITTREDGE. It stops all silting material altogether, does it?

Mr. NOBLE. It stops all silting material altogether. It is conceivable that some time in the future those basins may fill up somewhat, but that is pretty remote.

Senator KITTREDGE. And neither the silt nor the water goes into the canal basin?

Mr. NOBLE. No, sir.

Senator KITTREDGE. Is that right?

Mr. NOBLE. That is the way I understand it.

Senator MORGAN. Is it the project to throw those streams that empty into the Chagres River on the west back upon their sources and through their sources into the sea?

Mr. NOBLE. Yes, sir.

Senator MORGAN. To dam them up in the vicinity of the line of the canal, throw them back upon their sources, and through their sources over into the sea at some other point?

Mr. NOBLE. Yes.

Senator MORGAN. That is the project of protecting that canal?

Mr. NOBLE. Yes. That water, of course, will eventually flow down the Trinidad through this swamp and pass in the neighborhood of Gatun.

Senator MORGAN. Yes. That is the way in which that water is expected to be handled?

Mr. NOBLE. Yes, sir.

Senator MORGAN. And on the other side, up there above Gamboa, that water is expected to be controlled by a dam?

Mr. NOBLE. By a dam; yes, sir.

Senator MORGAN. And by underflow?

Mr. NOBLE. By an outlet weir or controlling works detached from the dam, through a rock site.

Senator MORGAN. Yes—through sluice gates?

Mr. NOBLE. Yes, sir.

Senator MORGAN. That comprises, really, the protection that is given to the sea-level plan against the waters of the Chagres River and its affluents?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. I wish you would go on now, Mr. Noble, and show what other rivers indicated on that map have been provided for by the majority, and what have not been.

Mr. NOBLE. I do not understand that any other streams have been provided for by the majority, other than those that I have pointed out.

Senator KITTREDGE. Point out the streams that will, in your judgment, affect the canal in the manner indicated.

Mr. NOBLE. I will point out all these coming in on this bank above this point, Senator, up as far as this [indicating].

Senator KITTREDGE. What are the streams there? Are you familiar with the geography?

Mr. NOBLE. I would have to read the names, and I am afraid I would sacrifice the pronunciation somewhat, Senator. I will simply take them off the map, if that will answer the purpose.

Senator KITTREDGE. Is that the only place?

Mr. NOBLE. Also all these on the south side, from Bohio up.

Senator KITTREDGE. Are not those taken care of by a divergence channel?

Mr. NOBLE. Only during construction. It is intended, after construction, to receive them directly into the canal.

Senator TALIAFERRO. Without passing them through dams?

Mr. NOBLE. By passing them through pools, in which, it is expected, the coarser material at least will be deposited.

Senator TALIAFERRO. As I understand you, then, all of the streams are provided for by that method? All that empty into the canal are

expected to pass through pools or dams, so as to take the coarser silt out before the water empties into the canal basin?

Mr. NOBLE. I think so.

Senator KITTREDGE. Do you regard that situation you have just described as a serious objection to the sea-level plan?

Mr. NOBLE. Only inasmuch as it makes a somewhat larger charge for maintenance; and, as I have already said, I do not consider that an impossible or an impracticable proposition at all.

Senator KITTREDGE. How large are these streams that enter into the canal basin that have not been provided for?

Mr. NOBLE. I could answer that question better perhaps by giving an estimate of the amount of water that might possibly be expected from them.

At Bohio it is estimated that the largest flood that has ever passed down the river may have been 136,000 or 140,000 cubic feet per second.

Senator KITTREDGE. Which river is that?

Mr. NOBLE. That is in all of the basin above Bohio.

Senator KITTREDGE. That includes the Chagres?

Mr. NOBLE. That includes the Chagres; certainly.

Senator KITTREDGE. It includes the water that comes from the territory that you say has been provided for by the majority?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. How much water passes down there naturally under present conditions?

Mr. NOBLE. About 136,000 cubic feet is the estimated maximum flood that has ever occurred. The experts differ somewhat.

Senator HOPKINS. Per second?

Mr. NOBLE. Per second. The experts differ somewhat as to that. I think the French Panama Canal Company—those estimates, I think, were prepared by General Abbot—considered that to be about 112,000, and Mr. Arthur Davis, of the Canal Commission service, estimated that it might be as much as 136,000. That variation in estimates is no more than might have been expected from the character of the data.

Senator KITTREDGE. How much of that is due to the Chagres and to the area that has been provided for by the majority?

Mr. NOBLE. If I can complete my answer, Senator—

Senator KITTREDGE. Certainly; I thought you had.

Mr. NOBLE. I was about to state that this flood of 136,000 second-feet was collected on an area of about 700 square miles. Of that area about 150 square miles—somewhere from 150 to 175 square miles—would still be tributary directly to the canal between Gamboa and Bohio after the construction of the sea-level canal, after excluding the areas which it is proposed to divert to the northward, and excluding the area above the site of the Gamboa dam.

The proportionate amount in regard to area only of a flood of 136,000 feet that would come from an area of 150 square miles would be about 29,000 cubic feet a second, and that, perhaps, is not far from the maximum amount that might be expected to come into the canal.

Senator MORGAN. Mr. Noble, I want to take a sort of a blackboard lesson from you, if you please, about this business. I do not know anything at all about it. That is Gamboa [indicating]?

Mr. NOBLE. That is Gamboa; yes, sir.

Senator MORGAN. There is a dam there?

Mr. NOBLE. Right here [indicating].

Senator MORGAN. This first body of water on this map—dead water—is made up of the waters that are impounded by a dam that crosses here somewhere?

Mr. NOBLE. Right there, sir [indicating].

Senator MORGAN. And that is the Gigante River?

Mr. NOBLE. The Cano Quebrado and the Quebranco.

Senator MORGAN. Where is the Gigante?

Mr. NOBLE. The Gigante is over there, sir [indicating].

Senator MORGAN. What is this here?

Mr. NOBLE. These are the three branches of the Gigante. This is called the Rio Gigantito and also the Gigante on the map.

Senator MORGAN. What is this?

Mr. NOBLE. This is the Quebranco.

Senator MORGAN. That is much the largest stream of any of them?

Mr. NOBLE. Yes, sir.

Senator MORGAN. The longest and with the most watershed?

Mr. NOBLE. Yes, sir.

Senator MORGAN. Now, what I want to ascertain is this: Is it practicable to make a drainage canal—I will call it—cut between Gamboa and the mouth of this river, or, at least, a dam on this river, and lead the waters that flow toward the Chagres above Gamboa out into the sea here or into the marshes?

Mr. NOBLE. I should think not. I should think that would be too formidable a proposition to undertake.

Senator MORGAN. It would cost too much?

Mr. NOBLE. I should think so.

Senator MORGAN. Are the physical difficulties very great?

Mr. NOBLE. Very great. It is a hilly country all the way through there, Senator.

Senator MORGAN. Yes. So that the sea-level canal would occupy the basin of the valley, the lower lands?

Mr. NOBLE. Yes, sir.

Senator MORGAN. And you think it would be too expensive to undertake to carry off the flood waters of the Chagres River by bringing them down to the mouth of this river or to the dam across this river and carrying them out this way to the sea?

Mr. NOBLE. I am giving you my impression only, Senator. I have not studied the matter.

Senator MORGAN. Certainly; that is what I am trying to get.

Mr. NOBLE. That is my impression.

Senator MORGAN. Now, on the other side here are the very high hills on the right bank of the Chagres, or what we might call the right bank of the sea-level canal between Bohio and Gamboa.

Mr. NOBLE. The country here is pretty hilly. I do not remember what the altitude of those hills is.

Senator MORGAN. Pretty hilly?

Mr. NOBLE. It is a pretty hilly country all along this valley.

Senator HOPKINS. Senator, let him state what valley it is, so that the report will show that.

Mr. NOBLE. Along the valley of the Chagres, between Gamboa and Bohio.

Senator MORGAN. What I am trying to get at, Mr. Noble, is whether, by hugging the hills, beginning at Bohio and running up to Gamboa, with the sea-level canal, you would not free that canal from almost all invasion by the waters that flow into the Chagres River on its left bank?

Mr. NOBLE. I am giving it as my impression only, for the reason that I have not studied it; but I should think that the construction of a canal of that sort would be rather difficult.

Senator MORGAN. Why?

Mr. NOBLE. I think it would be expensive; I think the course of it would be very crooked.

Senator MORGAN. If you cut off the hills on the side next to the river and threw the dump right into the river, forced it out so as to keep it away from the canal, would not the expense be reduced by the fact that you would free the canal from this water?

Mr. NOBLE. I could not say.

Senator MORGAN. You could not say? Have you ever studied that proposition?

Mr. NOBLE. No; I never have.

Senator MORGAN. You would not think it was impossible?

Mr. NOBLE. I would not say that it was impossible. I would not even say that it is impracticable; but I should expect it to be so.

Senator MORGAN. You would expect it to be so?

Mr. NOBLE. Yes, sir.

Senator MORGAN. But that proposition has never been studied by the Board or by either the majority or the minority?

Mr. NOBLE. No, sir.

Senator MORGAN. Nor this proposition of draining these waters off here?

Mr. NOBLE. Not to my knowledge. The majority may possibly have done so.

Senator MORGAN. Your studies have been confined to protecting the canal against these waters that flow into it on the left bank of the Chagres by dams, some of which impound the water and make no further disposition of it, and others of which impound the waters and throw them back from their sources into the sea?

Mr. NOBLE. I think that is the limit of the studies. I think that is the result, in a way, of the studies concerning the drainage on the west side of the route.

Senator MORGAN. If you were going to make a canal, for instance, on the plan of Bunau-Varilla, or any of these other persons who have suggested a lock canal, between Gamboa and, say, Miraflores or Pedro Miguel, where would you put the locks in the Chagres River?

Mr. NOBLE. Oh, I suppose that Obispo would be the natural location for one or more of the locks, and Pedro Miguel certainly for another, or very likely Miraflores, depending upon the number of locks built, and where the others would be in there I would not undertake to say without studying the maps.

Senator MORGAN. Then the difference between the lock that we are supposing might be put in there at Gamboa and that at Miraflores is about 10 miles, is it not?

Mr. NOBLE. Ten miles; yes, sir.

Senator MORGAN. If you were to dig a sea-level canal from the Bay of Limon up to, say, Obispo, or somewhere in that vicinity, until you

got to a good place to put in a lock, could the canal from there out be supplied by the water that would come from the Chagres River, impounded by the dam at Gamboa or in that vicinity?

Mr. NOBLE. Oh, I have no doubt it could be.

Senator MORGAN. You have no doubt of that?

Mr. NOBLE. No.

Senator MORGAN. Sufficient for all commercial purposes?

Mr. NOBLE. I think so; yes, sir.

Senator MORGAN. Between Gamboa and Miraflores?

Mr. NOBLE. I do; yes, sir.

Senator MORGAN. That is all I wanted to ask.

Senator KITTREDGE. Have you covered the area that is not controlled by dams?

Mr. NOBLE. I have stated that the maximum volume of water that might be expected to flow directly into the sea-level canal between Gamboa and Bohio might be estimated at 29,000 cubic feet per second.

Senator KITTREDGE. And from how many rivers or streams will that come?

Mr. NOBLE. I suppose it would come from a very large number of little streams—about all those that are shown on this map and, doubtless, a great many more in case of a storm making their way down those hillsides.

Senator KITTREDGE. You say, "a very large number?"

Mr. NOBLE. Yes.

Senator KITTREDGE. Can you give us any figures you have in mind?

Mr. NOBLE. No; I could do nothing better, Senator, than to read to you these principal ones from this map.

Senator KITTREDGE. Are there 50?

Mr. NOBLE. I should think there might be 50. There are not 50 shown, by any means. I think you would have water running into the canal at 50 points, without doubt.

Senator KITTREDGE. And wherever the water comes into the canal it first passes into a basin?

Mr. NOBLE. These smaller streams, that would simply be of a temporary nature, I presume would not.

Senator KITTREDGE. But the important streams?

Mr. NOBLE. The important streams, as I understand, according to the sea-level plan, would pass through settling basins.

Senator KITTREDGE. And then from the basins through a weir into the canal basin?

Mr. NOBLE. Into the canal.

Senator KITTREDGE. Is that right?

Mr. NOBLE. That is right, as I understand it.

Senator KITTREDGE. I think that is all I want to ask, Senator Hopkins, on that proposition.

Senator MORGAN. Mr. Noble, how long have you been acquainted with and connected with the subject of building a canal across the Isthmus of Panama?

Mr. NOBLE. My connection with it was as a member of the first Isthmian Canal Commission, my active connection being for about two years; and then again as a member of the present consulting board.

Senator MORGAN. Yes.

Mr. NOBLE. I had seen the Panama Canal before. I had given some little attention to it in 1895.

Senator MORGAN. You have studied the question in all of its phases of development up to date?

Mr. NOBLE. I have studied them; yes, sir.

Senator MORGAN. Closely and carefully?

Mr. NOBLE. I have never given very close attention to the old Lull project of 1874, or thereabouts.

Senator MORGAN. Were you in that?

Mr. NOBLE. Oh, no; no, sir. I have a copy of the report.

Senator MORGAN. That was the first report made by Menocal?

Mr. NOBLE. Yes, sir.

Senator MORGAN. That was an instrumental survey across there?

Mr. NOBLE. Yes, sir.

Senator MORGAN. I have his report, and I think I will call the attention of the committee to it after a while, as it will throw a great deal of light upon this question even now.

In your first study of the subject of a canal across the Isthmus, as a member of the Isthmian Canal Commission of which Admiral Walker was the president, did that Commission reach the conclusion that for any reason, and what reason it may have been, a sea-level canal across that Isthmus was impracticable?

Mr. NOBLE. I should want to see the language of the report before I would like to answer definitely a question of that kind. There is an expression in the report upon the subject of the feasibility of a sea-level canal. I can give a reference to it for the committee, if that would answer your question.

Senator MORGAN. We can get that at any time? That is in the report?

Mr. NOBLE. Yes; that is in the report.

Senator MORGAN. Whatever the language of the report is, that is the language to which you at that time subscribed?

Mr. NOBLE. Yes.

Senator MORGAN. But the Commission, as a commission, without any dissent, rejected the proposition of a sea-level canal at that time?

Mr. NOBLE. Yes, sir.

Senator MORGAN. The reasons being stated in the report of the Commission?

Mr. NOBLE. Briefly; yes, sir.

Senator MORGAN. Then you projected a canal with a dam at Bohio, which was the key of the situation?

Mr. NOBLE. Yes, sir.

Senator MORGAN. That plan was upon the proposition that if a dam at Bohio could not be established permanently and satisfactorily it was not practicable, within the knowledge or belief of that Commission, that a lock canal could be built there?

Mr. NOBLE. I do not think that that question, in that form, was before the Commission or was considered by them. Bohio was thought at that time to be a practicable site for a dam.

Senator MORGAN. Yes. The Commission studied it with all due care, of course. Now, since that time they seem, all of them, to have abandoned Bohio. Can you state the reason for that?

Mr. NOBLE. The situation at Bohio is not so favorable for a dam as was supposed at that time; and the minority believe that the con-

ditions at Gatun are more favorable than anybody at that time expected.

Senator MORGAN. Yes. Now, was it not the fact that Mr. Wallace, when he went there, conducted borings at Bohio upon the same general axis for a dam, and found that the former Commission had not reached what was supposed to be solid rock?

Mr. NOBLE. That is true.

Senator MORGAN. And that there was an interval of about 40 feet between the bottom of their borings and the bottom of the borings that he made?

Mr. NOBLE. I think that he found, between the points where the borings were taken by the Isthmian Canal Commission, places where the rock was deeper by 40 feet.

Senator MORGAN. Do you now think that it would be practicable to put in a dam at Bohio that would answer the same purpose that it was expected would be answered by the dam that was proposed by the Walker Commission?

Mr. NOBLE. I believe that a dam could be put in at Bohio that would answer the purpose.

Senator MORGAN. A dam could be put in there that would answer the purpose?

Mr. NOBLE. Yes, sir.

Senator MORGAN. If you were building a lock canal, which location would you prefer to-day—the location at Gatun or the one at Bohio?

Mr. NOBLE. The one at Gatun.

Senator MORGAN. Will you please state the reasons for that?

Mr. NOBLE. One reason is that I think the material at the site at Gatun is much less permeable than that at Bohio, and then I think that the resulting canal is much better by reason of adding about 10 miles of broad, open navigation to the canal route in place of a narrow cut.

Senator MORGAN. I have understood (perhaps I am mistaken about it) that in the borings that Mr. Wallace has made at Bohio he has gone down to what we call solid rock—that is, basalt, or some rock of that hard, tough nature; but in the borings at Gatun, if I correctly understand it, no rock has been reached at all?

Mr. NOBLE. It is believed to be the hard, indurated clay, somewhat of the character of that at Culebra.

Senator MORGAN. Yes; but that can not be called a rock?

Mr. NOBLE. It has been called a rock.

Senator MORGAN. Improperly, has it not?

Mr. NOBLE. Well, it is pretty hard to say, Senator. Some of it has the characteristics of rather soft rock. It seems to me sometimes that people make some difference as to the point of view of looking at it.

Senator MORGAN. But if it is rock, it is not rock of the strength and consistency of that which Wallace has developed by his borings at Bohio?

Mr. NOBLE. I should think not.

Senator MORGAN. It is not?

Mr. NOBLE. I should think not.

Senator MORGAN. As a foundation for a dam, I suppose the rock at Bohio is stronger and better, of course, than this hardpan or indurated clay or rock, or whatever it may be called, at Gatun?

Mr. NOBLE. I do not think that for an earth dam the difference is material at all.

Senator MORGAN. For an earth dam?

Mr. NOBLE. Yes.

Senator MORGAN. How will it be for a stone dam or a concrete dam?

Mr. NOBLE. For a concrete dam carried down to bed rock, assuming that a dam of that kind could be built at either place, I should think the material at Bohio was better.

Senator MORGAN. By "bed rock" do you mean this material at Gatun?

Mr. NOBLE. I was referring to it in that connection; yes, sir.

Senator MORGAN. But it is not rock.

Mr. NOBLE. I will say the material, if you please, then; the indurated clay at Gatun.

Senator MORGAN. About the hardest description that they can give to it is "indurated clay?"

Mr. NOBLE. Yes.

Senator MORGAN. Is not that so?

Mr. NOBLE. Yes; I should think so.

Senator MORGAN. So it is not rock at all. It was not an original formation of rock?

Mr. NOBLE. No; it is not a rock as we understand the term "rock" ordinarily; no, sir.

Senator MORGAN. That is what I am trying to get at—the common understanding—because we have to measure things by the common understanding. We do not understand it scientifically. Now, are you entirely satisfied, after a full and careful examination of the dam proposed by the minority of the consulting engineers at Gatun, that it is safe and satisfactory in every degree?

Mr. NOBLE. Entirely so.

Senator MORGAN. You think that is so?

Mr. NOBLE. I think that plan is entirely adequate for a dam at Gatun that will be safe and answer its purpose perfectly.

Senator MORGAN. Yes; and that the lock site with a flight of three locks is in every respect safe and sufficient for the accommodation of the ships that pass through?

Mr. NOBLE. Oh, I think so, sir. There is a little risk in any mechanical structure; but I think it is so small in the case of locks, I believe experience shows that so fully, that we may say with all reason that that is a safe and sufficient adjunct of navigation.

Senator MORGAN. Do you think that the proposition of Mr. Bates—which I suppose you have examined—is equally safe?

Mr. NOBLE. I think that Mr. Bates's various projects imply so many more mechanical structures with gradually cumulative objections, so that the result is not quite so good.

Senator MORGAN. But the principle upon which his dam is located at Gatun and the other dam at Mindi is the same that is adopted by the committee of consulting engineers? The principle is the same?

Mr. NOBLE. Oh, I think that an adequate dam can be built at Mindi, from what information I have.

Senator MORGAN. The difference between the two is simply in the elevation?

Mr. NOBLE. And the number of structures. If a dam was built at Mindi, it would be an embankment across that natural depression.

They would still require a dam across the Chagres, somewhere, I suppose, between Gatun and the sea.

Senator MORGAN. Yes. Mr. Bates puts it exactly on the axis of this dam that is proposed by the minority of the committee.

Mr. NOBLE. But in addition to that he would have to have a dam, I think, across the Chagres between Gatun and the sea, in order to hold up his Mindi level.

Senator MORGAN. Yes. Would that be three dams?

Mr. NOBLE. That would be three dams, by the time you got into the level above Gatun.

Senator MORGAN. Yes; and the dam across the Chagres, then, would be a controlling work?

Mr. NOBLE. Controlling works; yes, sir.

Senator MORGAN. I suppose you mean for the dam at Mindi?

Mr. NOBLE. Yes, sir.

Senator MORGAN. And also for the dam at Gatun?

Mr. NOBLE. And also for the dam at Gatun. There would have to be controlling works in connection with a dam at Gatun to discharge the water in the pool between Gatun and Mindi, and there would also have to be controlling works to discharge the water between the Mindi pool and the sea. It is possible, however, that a site might be found for a single controlling works from the Gatun level into the sea at some point farther to the westward.

Senator MORGAN. I am merely speaking of his plan. I want to get an understanding of it as you understand it.

Mr. NOBLE. Yes.

Senator MORGAN. The dam that he puts across the Chagres River below Gatun is built, as I understood him, on the plan and principle of the dam at Assouan, in Egypt; and it has gates for letting out the flood waters, for controlling the waters?

Mr. NOBLE. Yes, sir.

Senator MORGAN. And it is only a controlling dam, if I understand it?

Mr. NOBLE. I think that is so; that is my understanding.

Senator MORGAN. While that would be an additional structure, it would add to the security of both the dam at Gatun and the dam at Mindi, would it not?

Mr. NOBLE. It would be absolutely essential to the stability of a dam at Mindi, otherwise the water would overflow it and wash it out.

Senator MORGAN. Yes. I will not go into the relative expense, because that is a matter of calculation.

Mr. NOBLE. Yes.

Senator MORGAN. It is a matter that is all figured out, and the engineers have stated it, and I suppose Mr. Bates has stated it correctly. Now, taking the project of the minority of the Board of Consulting Engineers as presented to the Government and to this committee—taking that plan, which you say you think is entirely secure, and comparing it with a sea-level route from bay to bay, to which would you give the preference?

Mr. NOBLE. I should adhere to the preference expressed by the minority for the lock-level canal.

Senator MORGAN. You would give the preference to the lock-level canal over the sea-level?

Mr. NOBLE. Yes, sir.

Senator MORGAN. Would you have any difficulty in accepting, as an engineer, a plan of a canal that should be a sea-level canal as far as Gamboa, or in that vicinity, say Obispo, a lock canal from that point across to, say Miraflores, and a sea-level canal out to the Bay of Panama? Would you have any difficulty in accepting that?

Mr. NOBLE. I should think that would make a serviceable canal. It would sacrifice many of the advantages of the lock-level canal proposed by the minority, and it would have many of the disadvantages, as the minority considers them, of the sea-level route.

Senator MORGAN. The advantages that you speak of, proposed by the minority, that would be thus sacrificed, are the advantages of navigation, are they?

Mr. NOBLE. Yes, sir; mainly.

Senator MORGAN. Is there any other that you can think of, of an important character?

Mr. NOBLE. I think the formation of the lake from Gatun to Obispo simplifies the matter of maintenance considerably by providing a larger lake into which all the streams, large and small, would be received at a sufficient distance from the canal to prevent any material amount of deposit in it.

Senator MORGAN. So the advantage of safer and quicker navigation and the advantage in the cost of maintenance are the two leading features?

Mr. NOBLE. They are the leading features.

Senator MORGAN (continuing). That you would expect to obtain by substituting a lock canal with a dam at Gatun for a sea-level canal from Gamboa to Gatun?

Mr. NOBLE. Perhaps I should add, also, the materially greater cost of a canal built at sea level to Gamboa.

Senator MORGAN. The canalization would not be a very expensive work between the Bay of Limon and Gamboa at sea level, would it?

Mr. NOBLE. I think that would have to be answered by reference to the estimates of the majority in the report of the board.

Senator MORGAN. The heavy cost would come in between Bohio and Gamboa, then, in that project?

Mr. NOBLE. Yes; between Bohio and Gamboa.

Senator MORGAN. And that would be ditching?

Mr. NOBLE. Yes.

Senator MORGAN. But that could be done by dredging, could it not?

Mr. NOBLE. There is a great deal of rock in there, Senator.

Senator MORGAN. But can you not dredge rock as well as you can dig it and haul it out?

Mr. NOBLE. No; I think not.

Senator MORGAN. I do not mean that dredges can take it up and bodily carry it out; but can you not break it up and carry it out?

Mr. NOBLE. That can be done, Senator, but not so conveniently as in the dry, nor so cheaply.

Senator MORGAN. Would there not be a great advantage in getting rid of the spoil in favor of a sea-level canal between the Bay of Limon and Gamboa over a haul by railroad?

Mr. NOBLE. I could not say as to that without going into a detailed study of the matter, which I have not done.

Senator MORGAN. But would you not believe, as a general engineering proposition, that the dump that would be taken out of the sea-level canal—the spoil, we will call it—could be hauled off in barges into the sea and distributed out there in whatever way you chose to do it cheaper than you could do it by rail?

Mr. NOBLE. I would not undertake to say as to that. I can see a difficulty at once in carrying out that scheme, in this: That you could not commence your excavation at Culebra, perhaps, until after you had gotten your sea-level canal to Obispo.

Senator MORGAN. Now, on the other side, in the case that I am supposing of a sea-level canal, say, to Miraflores or Pedro Miguel (I do not know which is the preferable location) out to the Bay of Panama, you would put your sea-gate or lock at the point where the high lands stopped and the sea-level canal came in? You would not have to have any additional gate out in the direction of the islands in the Bay of Panama?

Mr. NOBLE. Oh, no, sir. By excavating a deep channel to Miraflores of course you could extend the sea level there.

Senator MORGAN. Yes. You can extend the sea-level canal to Miraflores without any gate to regulate or control it, except at Miraflores?

Mr. NOBLE. Oh, yes, sir.

Senator MORGAN. Yes. That is all I wanted to ask you.

Senator KITTREDGE. Going back, Mr. Noble, to the subject that you first touched upon, concerning the speed of vessels, in making the statement that you have upon that subject what size of ships did you use?

Mr. NOBLE. Can I see the report of the Board, Senator?

Senator KITTREDGE. Certainly.

Mr. NOBLE (after examining the report of the Consulting Board): We assume two sizes of ships, one 540 feet long by 60 feet beam and 32 feet draft. That represents somewhat closely the larger class of ships of the Union Castle Line, passing around the Cape of Good Hope from England.

Senator KITTREDGE. Is that about the largest type of ship now in use?

Mr. NOBLE. There are very few larger ships than that.

Senator KITTREDGE. I mean in common use.

Mr. NOBLE. There are very few larger ships than that, except on the North Atlantic routes. The other type (if I may complete my answer) was to be 700 feet long and 75 feet wide and 37 feet draft.

Senator KITTREDGE. Then in making the comparison upon which you based your statement regarding the difficulty of passage in the canal you took the larger size of ships?

Mr. NOBLE. The largest size of ships in ordinary use.

Senator KITTREDGE. How would it be for the ordinary vessels—the tramp boats?

Mr. NOBLE. The tramp boats of the present time would make the passage more quickly in either route, and that difference would be more large in favor of the sea-level route than of the lock route.

Senator KITTREDGE. To what size of ships do you think your criticism would apply regarding the passage of ships?

Mr. NOBLE. I do not know that I understand you.

Senator KITTREDGE. You say the tramp boats would pass easily?

Mr. NOBLE. Oh, in speaking of the tramp boat I was thinking of the ordinary size of tramp ship, that may be, say, approximately 350 feet long and 45 to 48 feet beam.

Senator KITTREDGE. Running up to what length?

Mr. NOBLE. Three hundred and fifty feet, say; anywhere less than 400, perhaps I should say.

Senator KITTREDGE. How would it be up to 500?

Mr. NOBLE. I do not know of any tramp ships—

Senator KITTREDGE. Well, other ships in use?

Mr. NOBLE. This particular dimension was 540 feet, you remember, Senator. I think the tramp ship, as we generally understand it, is almost invariably less than 400 feet long, and not much over and generally less than 50 feet beam.

Senator KITTREDGE. I was extending that to ships of larger dimensions. Is the next dimension the 540-foot ship you have mentioned?

Mr. NOBLE. Five hundred and forty by sixty.

Senator KITTREDGE. And is there any point below that where your criticism would not apply?

Mr. NOBLE. There must be a point below that where the time of passage would be more favorable to a sea-level canal. Without going into the matter in detail I could not say at what point that would be reached, but as you decrease the size of the ship the disadvantage of a relatively narrow waterway becomes less.

Senator KITTREDGE. Is there anything serious in even stopping a ship, as is done at Suez, to permit the passage of a ship going in the opposite direction?

Mr. NOBLE. It simply takes time.

Senator KITTREDGE. And not much time at that, does it?

Mr. NOBLE. That depends upon the distance between the passing places. That has all been taken into account in calculating these intervals given in this report.

Senator KITTREDGE. They have no difficulty in Suez in passing ships?

Mr. NOBLE. None whatever, except the delay.

Senator KITTREDGE. And the width of that canal now is about 118 feet, is it not?

Mr. NOBLE. I think that is it.

Senator KITTREDGE (continuing). As compared to a bottom width of 150 feet and a surface width of 200 feet on this canal, the sea-level canal. Is that right?

Mr. NOBLE. The surface width is considerably more than 200 feet in this canal, in the sea-level canal.

Senator KITTREDGE. In the sea-level canal?

Mr. NOBLE. In the sea-level canal the surface width would be considerably more than 200 feet everywhere except through the Culebra cut.

Senator KITTREDGE. What is the dimension of the canal through the Culebra cut under the lock plan?

Mr. NOBLE. Two hundred feet.

Senator KITTREDGE. Just the same?

Mr. NOBLE. Just the same; but the length is not anywhere nearly as much. That is to say, in the approaches to the deepest part of

the Culebra cut, in the lock canal, the channel is made considerably wider.

Senator KITTREDGE. For what distance is the width the same?

Mr. NOBLE. I think it is 4.7 miles.

Senator KITTREDGE. Are you quite sure that is the entire distance?

Mr. NOBLE. I would have to look at that.

Senator KITTREDGE. I wish you would, to be sure.

Mr. NOBLE (after examining report). That is the case, Senator.

Senator KITTREDGE. What is the distance?

Mr. NOBLE. 4.7 miles.

Senator KITTREDGE. How much greater rate of speed per hour will a boat be able to make in the lock plan than in the sea-level plan between the locks?

Mr. NOBLE. I have here a list of the rates of speed used in calculating these times of transit for each of these two types of ship in each channel width.

Senator HOPKINS. Just give those to the reporter.

Senator KITTREDGE. Is this list one that was prepared by yourself or by the minority together?

Mr. NOBLE. It is one that I prepared in studying up the matter for the minority. It does not appear in the minority records.

Senator KITTREDGE. And was it used?

Mr. NOBLE. It was used.

Senator KITTREDGE (continuing). In reaching your conclusions?

Mr. NOBLE. Yes, sir; it was taken by the minority.

Senator KITTREDGE. We will be very glad to hear them.

Mr. NOBLE. For a channel 1,000 feet wide by 45 feet deep—that is the channel in Lake Gatun—for example, from Bohio to Gatun—

Senator KITTREDGE. What is that distance?

Mr. NOBLE. It is rather a larger distance than that. I will have to give that correctly from the report here. [After examining report.] For 15.69 miles above Gatun the channel would be nowhere less than 1,000 feet wide at the bottom and 45 feet deep. Basing the calculation on those minimum dimensions, the estimated speed of a boat of type C (the boat of the smaller of the two types mentioned) is 10 miles an hour and of the larger 9 miles an hour.

Senator KITTREDGE. That is a gain of 1 mile an hour?

Mr. NOBLE. Of 1 mile; yes, sir.

Senator KITTREDGE. How much would you gain, then, in traveling that distance of 15 miles?

Mr. NOBLE. That comparison was between the two types of ship, Senator.

Senator KITTREDGE. Oh, between the two types of ship?

Mr. NOBLE. Yes, sir; that is followed by a width of 800 feet and the same depth for a distance of 3.86 miles.

Senator KITTREDGE. Now, then, let us take this 15-mile section.

Mr. NOBLE. Yes.

Senator KITTREDGE. What speed would you have in the sea-level canal for that distance?

Mr. NOBLE. These lengths are not quite coincident, Senator; but from $6\frac{1}{2}$ to 7 miles an hour for the smaller ship and $4\frac{1}{2}$ to 5 miles an hour for the larger ship.

Senator KITTREDGE. How much would you gain there in traversing that distance of 15 miles?

Mr. NOBLE. I shall have to estimate between those different forms of sea-level channel as well as I can, Senator, the difference of half a mile in the speed.

Senator KITTREDGE. Have not you it all figured out?

Mr. NOBLE. No; it is not all figured out here; no, sir.

Senator KITTREDGE. On what basis do you tell us that you make so much greater speed in the lock type than you do in the sea-level type?

Mr. NOBLE. It is based upon the ratio between the cross section of the channel and the cross section of the ship.

Senator KITTREDGE. Theoretically, then?

Mr. NOBLE. It is based upon observations taken by myself some years ago at the St. Clair Flats Canal and upon the investigations of German engineers on the movement of boats in canals. It is quite a complicated matter. It was treated at full length in the reports of the Board of Engineers on Deep Waterways and in the report of the first Isthmian Canal Commission, and that method is followed throughout.

Senator KITTREDGE. Then you have figured out this problem theoretically? Is that right?

Mr. NOBLE. I do not think the word "theoretically" is the proper one to use in that connection, because the figures are based upon a very large number of observations of facts.

Senator KITTREDGE. But you have not figured it out upon the basis that I have suggested, as I understand it?

Mr. NOBLE. I have taken the lengths of each one of these sections and applied the speeds resulting from those various observations.

Senator KITTREDGE. I notice in the minority report—I think it is the minority report—that the question of the use of buoys is considered. Do you contemplate the establishment of buoys from Gatun up to the point where the channel narrows?

Mr. NOBLE. At all the projecting points; certainly.

Senator KITTREDGE. Why is that?

Mr. NOBLE. That gives the navigator information as to the limit of deep water.

Senator KITTREDGE. How many buoys have you established in that 15-mile section, or how many do you contemplate?

Mr. NOBLE. We have not made any detailed estimate of it whatever.

Senator KITTREDGE. But you contemplate the location of them?

Mr. NOBLE. In general I could give you the locations where some of those buoys might be.

Senator KITTREDGE. Just tell us about where they would be, then, and how many there would be.

Mr. NOBLE. I would really not undertake to make a detailed layout for buoys in the channel.

Senator KITTREDGE. I understand; but it is a fact, is it not, that you contemplate the establishment of buoys?

Mr. NOBLE (indicating on map). Leaving Gatun, of course, it would be natural to put a buoy into this shoal water marked there; to put one certainly there; to put one, without doubt, here, to mark that point; to mark this at some suitable point along this ridge; to mark that, and to fully define this cut along here [indicating]. It might take four or five buoys in that section.

Senator KITTREDGE. The purpose of the location of those buoys is to indicate submerged banks, is it not?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. And that is just the point that the man used to riding the sea is afraid of, is he not?

Mr. NOBLE. It is the thing that he wants very much for safety, Senator.

Senator KITTREDGE. I understand; but he is afraid of submerged banks, is he not?

Mr. NOBLE. If they were not marked he would certainly be afraid to go anywhere near where he supposed them to exist; but if they are marked, and well marked, they would permit him to use the channel. That is a matter of everyday experience in the Lakes.

Senator KITTREDGE. I understand; but the point is that you use them?

Mr. NOBLE. Certainly.

Senator KITTREDGE. And you must guide your ship within the limits of those buoys?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. That is right, is it not?

Mr. NOBLE. That is true.

Senator HOPKINS. You say that is an everyday experience in the Great Lakes?

Mr. NOBLE. Yes, sir; the channels are all marked there by buoys. Between Lake Superior and Lake Erie there are between 40 and 50 limits of channels that are marked by buoys, and most of them are marked by gas buoys, so that they can be run by day or night. Most of them are marked—if I may go a bit further into the matter—

Senator HOPKINS. Yes.

Mr. NOBLE. Most of them are marked by center-line ranges, where they can be placed, so that a boat can see by ranges where the center of a channel is, and by the gas buoys where the limits of the channel are.

Senator SIMMONS. Is not that also a matter of everyday experience in the approaches of our harbors?

Mr. NOBLE. Oh, yes; wherever a ship approaches land.

Senator SIMMONS. And in the ordinary case of the harbors in the Lakes you can not mark those channels as clearly and distinctly by buoys as you can mark the channel off in this lake navigation here, can you?

Mr. NOBLE. I do not know that I catch that.

Senator SIMMONS. I say, in the approaches of our harbors you can not, by the use of buoys, mark off the channels quite so well as you could mark off the channels through this small lake here by buoys and lights, can you?

Mr. NOBLE. In approaching a harbor of course a boat would not know so definitely where it was.

Senator SIMMONS. That is what I mean.

Mr. NOBLE. But in this lake navigation, a vessel starting from a known point and having to go only a short distance before it picks up a buoy can not well go wrong.

Senator KITTREDGE. Did you read Mr. Bates's testimony?

Mr. NOBLE. No, sir.

Senator KITTREDGE. Or Mr. Parsons's?

Mr. NOBLE. No, sir.

Senator KITTREDGE. The statement was made by Mr. Bates, and confirmed by Mr. Parsons, that while the minority had in its report recommended the establishment of locks of navigable dimensions, 900 by 95 feet, the plans which have been sent up here disclose the fact that the usable length of these locks is only 790 feet. Have you any statement to make regarding that criticism of your plan?

Mr. NOBLE. The locks are estimated and, I suppose, drawn on the maps for a length between gates of 955 feet, of which 55 feet is ample to provide for the movement of the gate at the lower end of the lock, leaving 900 feet that is clearly usable.

Senator KITTREDGE. That is the supposition?

Mr. NOBLE. That is the fact, Senator.

Senator KITTREDGE. The statement is made by each of them that the plans do not show 900 feet, but, instead, 790 feet; and Mr. Parsons's statement was, given to us Tuesday, that he had made a personal examination of the plans in the office of the Commission. Have you any knowledge upon that subject?

Mr. NOBLE. No; I have no knowledge whatever. I made the plans of the lock myself, Senator; I made the estimates of them. I sketched out the plans of the lock personally, and I personally made the calculations of the quantities. They are based upon a length of 955 feet in every lock chamber and of 900 feet clear available space for a vessel, and the figures given in these estimates of the minority provide for that.

Senator HOPKINS. They contend that there is not space there for three such locks.

Senator KITTREDGE. That there is not hill enough.

Mr. NOBLE. I heard this morning that that question has been raised, and of course I do not know, but I do not think that the surveys have extended quite far enough, perhaps; but there are hills enough there at Gatun to put that lock in. That we have from the general information.

Senator DRYDEN. Mr. Noble, if it is true that the usable length of these locks is but 790 feet, and that it is practically impossible to make them longer, would it change your views as to the desirability and advisability of a lock canal?

Mr. NOBLE. Why. I can not conceive that that situation can arise, Senator. If the site there should be short there is plenty of ground in Gatun, by shifting the lock site laterally, to get any length of ground you want.

Senator DRYDEN. It was explained, as I understand it, that both ends of the locks would so project beyond the hills as to extend out into the air without any practical opportunity of furnishing the ends of those locks with supports, and that that is the reason why these locks can not be elongated.

Mr. NOBLE. I do not think that is so. There is a scarcity of topographical information at Gatun, but there is no doubt, as I understand it, that by shifting the locks laterally you can get in as much length there as you want. That range of hills is wide enough.

Senator DRYDEN. For the purpose of my question let us conclude that this criticism is correct, that the locks can not be lengthened beyond the scale proposed and beyond the length proposed. In view of the fact that we are already constructing vessels 780 feet in length,

would it materially detract from the desirability of a canal of this type if that should be found to be true?

Mr. NOBLE. I do not think that is the alternative, Senator. We might be against a situation the same as that of the Isthmian Canal Commission in 1900. The site at Bohio was only sufficient for two locks. The summit level was practically the same as now, and the Commission then decided to increase the lift rather than to incur some additional expense for moving the locks farther over. That remedy was available there. Now, that remedy is still available here.

Senator KITTREDGE. What do you mean by "increasing the lift?"

Mr. NOBLE. Increasing the lift so as to have two locks instead of three. I would much rather seek a location a little farther to the east.

Senator KITTREDGE. Increasing it to what extent?

Mr. NOBLE. Oh, I do not think you would have to go over there very far, Senator.

Senator KITTREDGE. I mean, increasing the lift to what extent?

Mr. NOBLE. Oh, I have no objections myself, after having studied the matter over very carefully, to overcoming the lift at Gatun in two lifts instead of three.

Senator KITTREDGE. Of 42½ feet each?

Mr. NOBLE. Of 42½ feet each. That is practically what we did at Bohio four years ago or five years ago.

Senator KITTREDGE. What is the highest lift of lock that you know of now in existence?

Mr. NOBLE. I think the highest lift that I know of to a certainty is—well, the highest lift that I have in mind is one planned and built, I think, at about 30 feet, somewhere in the South, on some one of the rivers; not a large ship canal, however, I think.

Senator HOPKINS. How many feet?

Mr. NOBLE. I think something over 30. In connection with the work of the Deep Waterways Board we had to design a flight of locks to overcome the great lift in the Niagara River at the falls, and we adopted there a lift, I think, of 40 feet and went into the calculations of strength of all the parts, the designs of the gates, and everything in connection with it in very great detail.

Senator KITTREDGE. To what extent had your Board and have you in your possession information concerning the character of the Gatun Hills in the vicinity of the proposed locks?

Mr. NOBLE. There are some borings in there, but I do not think they extend the full length of those locks. There was not time to get all that information.

Senator KITTREDGE. Do you not think it was desirable to have that information?

Mr. NOBLE. Oh, extremely.

Senator KITTREDGE. Do you not think that the minority of your board and this committee ought to have all possible information relating to that subject before adopting the lock plan?

Mr. NOBLE. We could not get it. We had no doubt whatever, Senator, that by one of those two alternatives, and no appreciable doubt that by adopting the first (that is, by changing the location), the difficulty could be met. That was a matter that we discussed at

the time. I was not aware that this site was short, and I do not think that we had the facts to show whether it was or not; but at the time that we were designing these locks, in view of the shortness of the time and the information, we decided to make a location where it seemed to be certain they could be built beyond a reasonable doubt, but with the further assurance that we could move them over where the hill formation was broader.

Senator KITTREDGE. The reason I ask this question, Mr. Noble, is this: You remember appearing before this committee four or five years ago?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. And recommending strongly the Bohio dam? On that occasion you told this committee that there was no doubt whatever about ability to go to bed rock and lay the foundations of the Bohio dam. That was right, was it not?

Mr. NOBLE. Yes; on the basis of the borings we had then; we were very certain.

Senator KITTREDGE. I understand. Now, then, when more careful examinations and borings were made, the fact was disclosed that instead of striking bed rock at 120 feet below sea level you had only struck boulders, or at least had not struck the deepest point at that place. That is right, is it not?

Mr. NOBLE. I think the latter is the case, Senator.

Senator KITTREDGE. And when more careful borings were made, the lowest point at the Bohio dam site was 168 feet below sea level. That is right, is it not?

Mr. NOBLE. I think that is correct; yes.

Senator KITTREDGE. Now, ought we not to have more careful borings and information concerning the character of the country at Gatun than the minority of the committee possessed and than you are able to give us now?

Mr. NOBLE. We believe that the information we have, Senator, is sufficient to make it certain that we can build the dam and the locks at Gatun. We do not think it is sufficient to enable us to say that these are the best possible locations in that neighborhood for those structures. But there is more doubt about the locks than there is about the dam in that connection, because the dam is determined very largely by the surface conditions and the topography.

Senator KITTREDGE. You say there is more doubt about the locks; what doubt is there?

Mr. NOBLE. Because the borings are not sufficient, are not what one would demand before constructing a lock. Before going to construct a lock there, Senator, we would take borings in that neighborhood and study up the whole topography, the whole situation, surface and subsurface, in great detail. That is a matter that would require many months.

Senator KITTREDGE. Suppose that the lock plan is adopted by Congress and then you make further and more careful investigations and the fact is developed that you can not build locks there—what then?

Mr. NOBLE. I do not think you can apprehend any such result as that, Senator.

Senator KITTREDGE. That is precisely the result that happened at Bohio, is it not?

Mr. NOBLE. It certainly is. The project of sinking caissons to full depth at Bohio is, I think, impracticable.

Senator KITTREDGE. And you advised that that be done at Bohio?

Mr. NOBLE. Yes; that is true.

Senator KITTREDGE. When you were before us four years ago?

Mr. NOBLE. Yes.

Senator KITTREDGE. And stated that you would not recommend any other type of plan at that point?

Mr. NOBLE. I think that you can make a water-tight dam at Bohio. I read what Mr. Burr has said in that connection before this committee, and I concur in that—that that is physically possible.

Senator KITTREDGE. I wish that during the recess, if we take one, Mr. Noble, you would make an examination of the records in the office of the Canal Commission and tell us whether you are mistaken, or Mr. Parsons and Mr. Bates, regarding the usable dimensions in length of the lock at Gatun.

Senator HOPKINS. My remembrance of Mr. Parson's testimony was that there was territory enough there, just as stated by Mr. Noble; and that if the present situs of the proposed lock was insufficient for a flight of three locks 900 feet in the clear, they could make a change so as to do that. Now, am I correct in that?

Senator KITTREDGE. There is not enough hill; they would have to go away out in the swamp.

Senator HOPKINS. No; my understanding was just the reverse.

Senator KITTREDGE. No; he said you would have to build up.

Senator HOPKINS. Where is his testimony in the afternoon? Have you that evidence printed, Mr. Chairman?

The CHAIRMAN. I think that is it [handing testimony to Senator Hopkins].

Senator KITTREDGE. Let me ask you another question, Mr. Noble. Tell us the plans of the locks which you devised. Did you have any safety gates?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. What were the dimensions of those?

Mr. NOBLE. The same as the lock gates.

Senator KITTREDGE. And you regard them as essential and necessary in the construction of the locks?

Mr. NOBLE. They have not been used heretofore, Senator; but we thought that in a great work of this kind it would be advisable to use them.

Senator KITTREDGE. And you agreed that that should be done in this case?

Mr. NOBLE. Oh, yes.

Senator KITTREDGE. I notice in the majority report the statement that by a vote of 11 to 2 the size of locks, if locks were used, was to be in usable dimensions, 1,000 feet by 100. That is right, is it not?

Mr. NOBLE. That is right.

Senator KITTREDGE. Why was that reduced to 995 feet, usable dimensions?

Mr. NOBLE. On further discussion of the matter, the minority came to the unanimous opinion that that would be sufficient to meet the requirements of the act.

Senator KITTREDGE. Was that discussion had in full board?

Mr. NOBLE. No; that was the discussion of the minority, after the board had divided on the main issue of a sea-level versus a lock-level canal.

Senator KITTREDGE. I turn to the testimony, Mr. Noble, that you gave before this committee four or five years ago; and, in speaking of the Bohio dam, I read you the following:

"Senator HARRIS. That no form that the water passed through or under could be safely depended upon?"

"Mr. NOBLE. I am not at all sure that there would be any very great danger of the destruction of such a dam, although the risk would be conceivable, perhaps, even if a small area were thus exposed; but the amount of water passing under the dam would increase with the area of cross section of the sand through which the water would pass, and I think that if the dam were not made impermeable in the whole section, the amount of filtration might be so great as possibly to cause trouble with the water supply."

Do you still subscribe to that?

Mr. NOBLE. No; I have gone into the matter considerably since that time, and have made use of the latest investigations in regard to the amount of water that will pass through a given thickness of sand; and I must say that I have been very thoroughly convinced by the arguments that have been presented.

Senator KITTREDGE. By whom?

Mr. NOBLE. By Mr. Stearns, mainly; by Mr. Morison to some extent.

Senator KITTREDGE. How long before Mr. Morison's death did you discuss this question with him?

Mr. NOBLE. Perhaps a year or so before his death. I think that my mind was still open on the subject until Mr. Stearns presented his experiments in great detail. I saw the samples of the materials used in the filtering experiments; and then, taking into consideration the dimensions of the dam that the minority proposes, unprecedented in width, I can not see any possibility of any amount of water getting through there that will affect in any appreciable degree the water supply of that canal, or that will involve any hazard whatever to the structure.

Senator KITTREDGE. I read further from your testimony in that connection, Mr. Noble, in answer to a question by Senator Hawley. I will read his question:

"I should suppose a temporary dam would require as much protection against the seepage and leaking as the permanent dam.

"Mr. NOBLE. It is necessary that the permanent dam shall be free from much seepage to maintain the water supply, but the temporary dam would simply be used during construction, and moderate seepage would not be a very important matter.

"The CHAIRMAN. Then I understand your answer to mean that you would not consider a dam sufficiently permanent that admitted of seepage through the strata upon which it rested?

"Mr. NOBLE. I should not consider it to possess the requisite amount of certainty as a protection for that navigation. I could not say that it would give way, and I could not predict with certainty that the seepage would be very serious, but I should apprehend it."

You were then speaking of the Bohio dam. Do you still subscribe to the statements that you made there?

Mr. NOBLE. I think the seepage through the Bohio dam would be more than it would be under the Gatun dam for several reasons, Senator. One is that the material there, as shown by the borings, is coarser, a larger proportion of it; another is that the material there, as shown by borings, is, in the immediate vicinity of the dam, in continuous connection with the river. But I will say this, that my apprehensions in regard to the amount of water that will pass under a dam through sand and gravel are much less than they were five or six years ago. I do not believe that with the width of the Gatun dam any appreciable amount of water can pass.

Now, Mr. Stearns can go into that very much more fully with you than I can, but I will state—

Senator KITTREDGE. He will be here.

Mr. NOBLE. I will state frankly that I have undergone a change of opinion in the last four or five years just on that point.

Senator KITTREDGE. You have changed your opinion?

Mr. NOBLE. That I have less apprehensions of the dangers of seepage through gravelly, sandy material than I had at that time.

Senator KITTREDGE. But at Gatun, Mr. Noble, while the borings have been to the depth of 258 feet, you have not yet reached the point of solid rock? That is right, is it not?

Mr. NOBLE. We have reached the point of water-tight material, I think, Senator.

Senator KITTREDGE. You have reached the point of the indurated clay?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. Never below that, have you?

Mr. NOBLE. I think not.

Senator KITTREDGE. You have not gone through the indurated clay to solid rock at any point at Gatun, have you?

Mr. NOBLE. Not to my knowledge; I think not.

Senator KITTREDGE. Can you assure us that if you go through that clay into solid rock you will find any different conditions than were developed at Bohio after further and more careful investigations were made?

Mr. NOBLE. If we should have a dam there, Senator, half a mile wide, with the amount of fine material that we know to exist at Gatun immediately under the surface of the earth, I should not apprehend any danger from any amount of seepage that we could reasonably anticipate, and I could conceive of no possible danger from any material we should find below the indurated clay.

Senator KITTREDGE. How many borings were made across the Chagres Valley under the location of the Gatun dam?

Mr. NOBLE. I can not answer that offhand.

Senator KITTREDGE. Will you not look at the maps and answer my question?

Mr. NOBLE. I do not think I can answer that from this drawing. This purports to give the number of new borings at Gatun. Those shown on the profile are—

Senator MORGAN. There is a blueprint there that gives it more completely.

Mr. NOBLE (after examining papers). If I count correctly, Senator, there are 36.

Senator KITTREDGE. That includes the borings under the Gatun locks, does it not?

Mr. NOBLE. I would have to look at the contour maps to get that. I think not. Very likely this will show it.

Senator KITTREDGE. I think you will find that that covers the borings under the locks, as you originally planned them out, as well as across the valley.

Mr. NOBLE. I could not say as to that from this plat.

Senator KITTREDGE. I will show you Mr. Stevens's testimony upon that subject; perhaps you can tell me from that. I am not particular to have the exact number. Leave the lock feature out of the question; just take it under the dam.

Mr. NOBLE (after examining papers). If I count correctly, Senator, there are 39 borings taken at the site of the dam, of which 32 were on a continuous line across the site.

Senator KITTREDGE. How many?

Mr. NOBLE. Thirty-two, and about five or six more were on a continuation of that line, as I think it might be considered, probably.

Senator KITTREDGE. Those are marked upon plate what?

Mr. NOBLE. Those are marked upon plates 11 and 12.

Senator KITTREDGE. How many borings were made at the site at Gamboa at the time you gave your testimony four or five years ago?

Mr. NOBLE. At Bohio?

Senator KITTREDGE. Yes.

Mr. NOBLE. I would have to count them up.

Senator KITTREDGE. About how many?

Mr. NOBLE. Oh, they were three or four hundred feet apart, as I remember it. I would have to trust to memory for that.

Senator KITTREDGE. And the distance there between the extreme ends of the dam was what?

Mr. NOBLE. I would have to count that up.

Senator KITTREDGE. About 3,000 feet, was it not?

Mr. NOBLE. Somewhere in that neighborhood; yes, sir.

Senator KITTREDGE. The distance between the ends of this dam is what?

Mr. NOBLE. I believe it is about 7,000 feet.

Senator KITTREDGE. It is 7,700, is it not? I think that figure is stated in your report.

Mr. NOBLE. If it is stated in the report, of course that is correct. I think likely, following up the crest line of the dam.

Senator KITTREDGE. And in the distance of 7,700 feet—a mile and a half, in round figures—you have made how many borings?

Mr. NOBLE. Thirty-two, I think, on the transverse line.

Senator KITTREDGE. And how far apart are those borings?

Mr. NOBLE. The distances vary.

Senator KITTREDGE. From what?

Mr. NOBLE. I do not see any distance here that appears to exceed about 300 feet. Here is one, I think, of about 400 feet, on the top of the hill. Now, they vary there about 200 feet apart, and in one place I think they are 400 feet apart.

Senator KITTREDGE. Then they run from 200 to 400 feet apart there—is that right?

Mr. NOBLE. In the closest part they are 100 feet apart. I can give those dimensions exactly here. The closest pair that I note here are 97 feet apart.

Senator KITTREDGE. Where is that point?

Mr. NOBLE. Shall I describe it by stations, Senator? It is in the shallower of the two troughs. The next, the distance next to that between two completed borings, omitting the one that was only sunk a few feet, is 393 feet.

Senator KITTREDGE. And that is in the same trough, is it not?

Mr. NOBLE. In the same trough; yes, sir.

Senator KITTREDGE. And to what depth do those borings go?

Mr. NOBLE. One is about 170 feet and the other about 180. The borings go to about 180 feet below mean tide.

Senator KITTREDGE. Do you find any point upon that map indicating borings at a shorter distance?

Mr. NOBLE. Shorter than 97 feet?

Senator KITTREDGE. Yes. Look at the trough where it runs down to 258 feet.

Mr. NOBLE. No; I do not see anything nearer than that.

Senator KITTREDGE. What is the distance between the borings in that trough where the maximum depth is 258 feet?

Mr. NOBLE. The maximum distance is 209 feet. That is the maximum distance in the trough.

Senator KITTREDGE. And what is the maximum distance, you say, between any of these borings—400 feet?

Mr. NOBLE. Three hundred and ninety-three feet, I think.

Senator KITTREDGE. Three hundred and ninety-three feet. Can you assure us that borings nearer together would not disclose the same condition of affairs that the careful borings made by Mr. Wallace, or under his direction, indicated at Bohio?

Mr. NOBLE. I should not expect them to, Senator.

Senator KITTREDGE. We did not expect it at Bohio, did we?

Mr. NOBLE. No, no; but the formation here, I think, would lead to less doubt than it did at Bohio. At Bohio the formation was of volcanic rock, and here it is of clay. As a matter of absolute mathematical certainty we can not tell that without more borings; but I can not conceive of any material down there that would affect the stability of the Gatun dam.

Senator KITTREDGE. The great trouble regarding the sand and gravel at Bohio was developed when you reached the depth of 168 feet, was it not?

Mr. NOBLE. We found a greater depth of sand and of gravel at Bohio, and an additional depth of enough to make the methods which we proposed to use for creating an impermeable curtain there impracticable.

Senator KITTREDGE. So you advised against the construction of a dam at Bohio for that reason?

Mr. NOBLE. I think the Gatun site is the better one. I think Gatun, all around, is the better site. I think that with my present information I would advise the construction of a dam at Gatun even if the conditions at Bohio were exactly what we had supposed them to be in 1900.

Senator HOPKINS. But, as I understand you, a safe dam could be built at Bohio?

Mr. NOBLE. Oh, I think so.

Senator MORGAN. Did the commission—I will call it the joint commission; I do not know how to denominate it—did the Board of Consulting Engineers take into consideration and study the question of the construction of a dam at Bohio, at the place or near the place and on the plan that was reported favorably by the Isthmian Canal Commission?

Mr. NOBLE. I think the site that the Board used there was the site adopted by the Frenchmen. Perhaps General Davis can tell me about that.

General DAVIS. What is that?

Mr. NOBLE. The site that was studied at Bohio was the old French site, was it not?

General DAVIS. Oh, yes; yes.

Mr. NOBLE. The site adopted by the Isthmian Canal Commission in 1900 was chosen for the reason that the borings indicated rock farther down at the French site than at the one subsequently developed.

Senator KITTREDGE. Some 40 feet lower?

Mr. NOBLE. Yes. Now, Mr. Wallace's further borings showed that there was not any very material difference; the rock was a little lower down than had been supposed at the French site and very much lower down than had been supposed at the Commission's site.

Senator KITTREDGE. I have understood you—you can correct me if I am wrong about it—to say that the Board of Consulting Engineers—that is, the Board of which you were a member—discarded the plan of a dam at Bohio in consequence of the fact that Mr. Wallace had, by more complete borings, found that they had not struck solid rock within 40 feet, or about 40 feet, of the distance that they reported?

Mr. NOBLE. I think, Senator, that the minority would have chosen Gatun anyway.

Senator KITTREDGE. Anyway? .

Mr. NOBLE. Yes.

Senator KITTREDGE. In preference to Bohio?

Mr. NOBLE. In preference to Bohio.

Senator KITTREDGE. So that the Bohio plan was really not studied carefully by the Commission?

Mr. NOBLE. Oh, I think so. I think it was studied carefully by the Commission, but—

Senator KITTREDGE. And rejected?

Mr. NOBLE. And the other preferred.

Senator KITTREDGE. Yes; rejected in favor of the Gatun proposition?

Mr. NOBLE. Yes.

The CHAIRMAN. Mr. Noble, what would be the objection to putting two locks at Gatun instead of three and making them 1,000 feet in length? What would be the objection to that?

Mr. NOBLE. Aside from the objection to the 1,000 feet in length, which is not a very serious one, of course, as far as I am concerned, in my opinion, there would not be any serious objection. I have no fear of a 42-foot lift.

The CHAIRMAN. That would be the only one?

Mr. NOBLE. That would be the only one; yes. I think that is true; I can think of no other.

Senator KITTREDGE. That would be an unusual and an untried structure, however; would it not?

Mr. NOBLE. Yes; but not an unconsidered one, Senator, because the previous Isthmian Canal Commission had considered the same thing.

Senator HOPKINS. You would not consider it a dangerous lift then?

Mr. NOBLE. Oh, no. I look upon it as exactly parallel to the problem of a bridge span. If you increase the span, you must increase the cross section, increase the strength in proportion.

Senator HOPKINS. It is on the same principle; if you increase the strength of the thousand-foot lock where you raise 42 feet, it is just as easy to raise 42 feet as it is 20 or 30?

Mr. NOBLE. Oh, yes.

Senator HOPKINS. My information is (and I will ask you whether I am correct or not) that at the Soo they have increased the lift from 10 to 20 feet.

Mr. NOBLE. Yes, sir. The old State locks at the Soo, opened for navigation in 1855, overcame that lift, which then was about 18 feet in two locks, dividing it about equally. At that time that was considered a rather high lift for a lock. Then in 1870, when the improvements were undertaken there by the General Government, it was decided in the new lock, parallel to the old ones, to adopt a single lift, and the wisdom of that was very strongly questioned. It was unprecedented at that time, and there were just as many doubters, I think, about the feasibility and propriety of a lift of 18 feet then as there would be about a 42-foot lift now. It worked perfectly successfully.

The CHAIRMAN. As I understand it, the whole plan at Gatun is somewhat unusual, is it not, anyway, for the three locks? The proposition to put in two would not be much more unusual than it would be to put in three, would it?

Mr. NOBLE. In respect to lifts, Senator, it is an advance from any former practice. There is another objection to a 42-foot lift that might be brought up, but in this case it is not important. That is, that it requires a little more water, of course, to fill a lock 42 feet deep than it does to fill one 30 feet deep; and you would sooner have to supply an additional water supply as commerce increased.

The CHAIRMAN. It would take no more water to fill two than it would three, would it?

Mr. NOBLE. May I illustrate that a little bit in detail? Perhaps it will not take too much time.

The CHAIRMAN. Certainly; certainly.

Mr. NOBLE. Suppose, Senator, that a vessel were bound down from the summit level, and that a boat had just gone down. Suppose a boat had just gone down, leaving the water all at the lower levels. In the lower lock, of course, it would be at the level of the lower pool. In the middle lock it would be one lift above that, and at the upper lock it would be one lift above that, and that would be a lift below the summit level. Then suppose another boat followed it. They would, in the first place, have to fill the upper lock. That would take, in case of the three-lock system, we will say, 30 vertical feet of water.

Now, when the upper gates are closed, the next operation would be

to open the valves and fill the lock below; and that chamber full of water, that 30 feet of water in the upper lock, would raise the water in the middle lock until they would be at a common level. Then the vessel would pass through, and so on. Now, that means that they draw out one lock full from the upper level in passing that ship down. In the case of the 42-foot lift that lock full would be measured by the 42 vertical feet.

Senator KITTREDGE. Do you know of any locks constructed as these are supposed to be, in flights, with a lift aggregating 85 feet?

Mr. NOBLE. At Lockport the canal locks are about that; I think there are 10 or 11 lifts, however.

Senator KITTREDGE. What are the usable dimensions of those locks?

Mr. NOBLE. There is no ship canal anywhere with a flight of three locks overcoming a lift of 85 feet.

Senator KITTREDGE. That is what I meant.

Mr. NOBLE. There is no large ship canal; no, sir.

Senator KITTREDGE. Is there any large ship canal that you know of where they have locks in flights of two, with an aggregate lift of 60 feet—30 feet each?

Mr. NOBLE. No, sir; no, sir.

Senator KITTREDGE. What is the largest lock for a ship canal now in use?

Mr. NOBLE. I think probably the Soo Canal has the largest lock and the largest lift.

Senator KITTREDGE. What are the dimensions of that lock?

Mr. NOBLE. Eight hundred feet long and 100 feet wide, with a lift of probably, I might say, 20 feet. It varies a little.

Senator KITTREDGE. And that is a single lock?

Mr. NOBLE. That is a single lock; yes, sir.

Senator KITTREDGE. By "800 feet" do you mean usable dimensions?

Mr. NOBLE. No, sir; that is the length between the gates.

Senator KITTREDGE. What is the usable dimension of that lock?

Mr. NOBLE. That would be about 750 feet.

Senator HOPKINS. Mr. Noble, you know of no such canal in existence, do you, as is proposed either by the majority or the minority of this Board of Consulting Engineers?

Mr. NOBLE. No, sir.

Senator HOPKINS. So that the construction of the canal on either type, either the sea level or the lock level, is exceptional?

Mr. NOBLE. The Panama Canal certainly is exceptional, no matter how built.

Senator KITTREDGE. Yes; and the locks that are spoken of here at the Gatun dam are no more exceptional than the construction of the entire dam is exceptional, are they?

Mr. NOBLE. I am not sure as to that, Senator. The Suez Canal is a sea-level canal, of course, and has been excavated for a greater length than the Panama Canal; and I should think that the parallel between Suez and Panama at sea level would be closer than between any two lock canals.

Senator HOPKINS. Still the climate, the topography of the country, and almost every element connected with the construction of the Panama Canal differ very widely from the Suez Canal?

Mr. NOBLE. Oh, those conditions, taken altogether, as a whole project, make it unprecedented, of course.

Senator MORGAN. You have never had any connection with this work as a commissioner for the construction of the canal?

Mr. NOBLE. No, sir.

Senator MORGAN. You declined an appointment on that Commission?

Mr. NOBLE. Yes, sir.

Senator MORGAN. Your work on it was confined entirely to what we call the Walker commission of examination, which made its report—this report here—and then, afterwards, to your service on the Board of Consulting Engineers?

Mr. NOBLE. That is my entire official connection with the Panama Canal.

Senator MORGAN. That is what I supposed.

Senator KITTREDGE. You were also a member of the Ludlow Commission?

Mr. NOBLE. Yes. That did not relate to the Panama Canal, however.

Senator KITTREDGE. I understand; I simply mentioned that as showing your experience in matters of this kind.

Mr. NOBLE. Yes.

(The committee thereupon took a recess until 2 o'clock p. m.)

AFTER RECESS.

Senator KITTREDGE. Mr. Noble, have you, during the recess, examined the drawings in the office of the Canal Commission in reference to the usable length of the locks proposed at Gatun?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. What do they show?

Mr. NOBLE. The published drawing seems to have been a draftsman's error in showing the lock chambers too short.

Senator KITTREDGE. What do those drawings show?

Senator HOPKINS. Let him furnish his answer.

Mr. NOBLE. I did not measure this. This information came from General Davis. The draftsmen also informed me that they had made a mistake and made the drawings too short; but the borings have not developed a lock site long enough for three locks.

Senator KITTREDGE. They have not?

Mr. NOBLE. No, sir.

Senator KITTREDGE. To what length have those borings developed a lock site?

Mr. NOBLE. They have developed a lock site long enough for two locks and something over.

Senator KITTREDGE. Of what length?

Mr. NOBLE. Of a usable length of 900 feet.

Senator KITTREDGE. That is the length that the majority of the Board suggests?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. This morning, just before recess, the question of increased lift was discussed—that is, having two locks of an aggregate lift of 85 feet. What effect would locks of that size have upon the use of water?

Mr. NOBLE. They require more water.

Senator KITTREDGE. How much more?

Mr. NOBLE. They require for the Atlantic side in the proportion of 28 or 29 to 42½. That would be approximately 50 per cent more for the Atlantic locks.

Senator KITTREDGE. In other words, if you have two locks with an aggregate lift of 85 feet, you would require 50 per cent more water than for three locks?

Mr. NOBLE. On that side—on the Atlantic slope.

Senator KITTREDGE. That is what I mean.

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. Three locks, according to the plan proposed by the minority—

Mr. NOBLE. For lockage purposes only, you understand.

Senator KITTREDGE. I understand. That is what I was talking about.

Mr. NOBLE. Not the water supply.

Senator KITTREDGE. Well, the supply for lockage purposes?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. That is right?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. Was the question of water supply considered by the minority?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. You determined it to be ample for the lockage of three locks?

Mr. NOBLE. Yes, sir.

Senator KITTREDGE. Is there any doubt about its being sufficient where you increase the necessity for water as you would if the locks were increased from 30 to 42½ feet?

Mr. NOBLE. It would be necessary to provide an additional water supply a little earlier than it would under the three-lock plan.

Senator HOPKINS. What do you mean by a little earlier?

Mr. NOBLE. With the three-lock plan the water supply—my numbers may not be correct—but the water supply was adequate, we will say, for 25 passages per day; if we had to use more water for lockage purposes, it would not be available for quite so many, and when traffic developed up to that extent we would have to develop an additional water supply somewhere on the upper Chagres.

Senator HOPKINS. An additional water supply?

Mr. NOBLE. We would have to impound some water somewhere on the upper Chagres.

Senator HOPKINS. Is there any trouble about that?

Mr. NOBLE. No, sir.

Senator HOPKINS. No practical trouble would be experienced on that account, then?

Mr. NOBLE. No, sir; there would only be the cost of building a dam.

Senator KITTREDGE. Whereabouts had you in mind to build that structure?

Mr. NOBLE. At Alhajuela.

Senator KITTREDGE. How far is that from Gamboa?

Mr. NOBLE. About 10 or 12 miles.

Senator KITTREDGE. And what are the opportunities for the construction of a dam in that vicinity?

Mr. NOBLE. There is an excellent site at Alhajuela.

Senator KITTREDGE. And the dimensions are what?

Mr. NOBLE. I would have to go to the old profile for that. It was the old site selected by the French Panama Canal Company and studied by the Isthmian Canal Commission. I have examined the site. It is a rocky gorge, with rock in sight in most places on the sides of the gorge, and at no great depth in the valley, as determined by the French borings.

Senator KITTREDGE. The borings and the record of them at the Gatun dam site disclose the presence of water at different depths, do they not?

Mr. NOBLE. I believe so; yes, sir.

Senator KITTREDGE. I wish you would look on plate 12 and point out in what manner they are indicated.

Mr. NOBLE. I am not sure that they are indicated, Senator.

General DAVIS. Let me help you.

Senator KITTREDGE. That is not plate 12 there.

General DAVIS. Not that plate. This is plate 12, where they should be shown. The points where the water emerges have been omitted from this sheet.

Mr. NOBLE. It does not appear to be shown on the plate.

Senator KITTREDGE. Those were the maps sent us, as you understand?

Mr. NOBLE. Yes.

Senator KITTREDGE. Can you account for the fact that they are not shown on that?

Mr. NOBLE. No; I am not familiar with the manner in which these drawings were made up.

General DAVIS. Here is the original [indicating].

Mr. NOBLE. No, sir; I can not explain that.

Senator KITTREDGE. I return again to your testimony——

Senator HOPKINS. Before you leave that, Senator, may I ask a question?

Senator KITTREDGE. Certainly.

Senator HOPKINS. You have the original map before you, have you?

Mr. NOBLE. I am not perfectly sure about this. Perhaps I should state to the committee what I stated to the Senator a short time ago. That the work to be done by the minority in preparing their report involved so much detail that we were obliged to divide up our work, and this part of the work was attended to by one of the other members.

Senator KITTREDGE. Who did this work?

Mr. NOBLE. I am not sure. I think Mr. Stearns did, probably, who will be here to-morrow.

Senator HOPKINS. Would the fact that the profile shows water there in those different borings change the opinion that you have given as a member of the minority, and would it change the opinion that you have expressed here to-day regarding the feasibility of the dam and locks at Gatun and the construction of a lock-level canal, as proposed by the minority?

Mr. NOBLE. Not at all.

Senator KITTREDGE. In that connection, Mr. Noble, I read from your testimony given before this committee four or five years ago. Speaking of the foundation at Bohio——

Senator HOPKINS. Have you questioned him all you are going to on Gatun and those locks?

Senator KITTREDGE. No.

Senator HOPKINS. All right. I thought we had better keep that testimony together, to develop it. If you are coming back to it it is all right.

Senator KITTREDGE. I had it in mind to come back to it.

Senator HOPKINS. All right.

Senator KITTREDGE. When I referred to this subject this morning I had read you your answer in reference to the Bohio dam (reading):

"I should not consider it to possess the requisite amount of certainty as a protection for that navigation. I could not say that it would give way, and I could not predict with certainty that the seepage would be very serious, but I should apprehend it.

"The CHAIRMAN. You would not advise the building of a dam upon such a foundation?

"Mr. NOBLE. No, sir."

Do you entertain that opinion to-day?

Mr. NOBLE. The situation here at Gatun is more favorable than it is at Bohio, in the first place. In the second place, in the interval of four or five years I have changed my opinion somewhat as to the advisability of building a dam of earth, if it is made of great dimensions. I think that the amount of seepage depends upon the distance the water has to travel, and for such a great distance as proposed for the Gatun dam that that would be insignificant.

Senator KITTREDGE. On account of the weight?

Mr. NOBLE. On account not only of the weight, but of the distance through which the water would have to travel. To go into the matter a little further, the amount of water which will pass through permeable material is dependent upon two factors—first, upon the head of water exerting pressure, and, second, upon the distance which the water has to move exerting resistance. And in this case that ratio is so small that the amount of seepage would be very small.

Senator KITTREDGE. This testimony was given before this committee four years ago last month, and at that time you had just completed or practically completed your service as a member of the Isthmian Canal Commission, and had visited the Isthmus and carefully studied all the conditions relating to this route. That is right, is it?

Mr. NOBLE. That is true.

Senator KITTREDGE. What studies have you given this subject since that time until you became a member of the Board of Consulting Engineers?

Mr. NOBLE. More, perhaps, since becoming a member of the Board of Consulting Engineers than before. Still, I have during that four years read and studied to quite an extent, and have heard discussions by others of the possible amount of seepage, the thought being to determine by experiment the amount of water that would go through a given mass of material. That has been in the way of definite information from which my opinion has been changed somewhat.

Senator KITTREDGE. To what extent has your opinion changed?

Mr. NOBLE. To the extent that I should think that a dam at Gatun on that foundation would be an adequate dam for the purposes of the

Panama Canal. Such calculations as I have made and as Mr. Stearns has made, who has given this matter more attention, perhaps, than anybody else in this country, show very clearly, I think, that the seepage would be negligible.

Senator KITTREDGE. Do you consider that the danger of water running under the dam from seepage is the only danger to which it would be subjected?

Mr. NOBLE. With a dam of that magnitude I do not think it is a danger; but I do not think the dam can be moved out of its place by this water pressure. I do not think it can be washed down. I think it is safer against earthquakes than anything else that could be put there; and the only other danger that I think of for the moment is the danger of seepage underneath, which I think is absolutely negligible. As far as the danger is concerned, I can not conceive that there is any. The calculations based upon the experiments on filtration would seem to indicate that the velocity there would only be a few feet a day.

Senator KITTREDGE. Is the filtration comparison a fair one with reference to a structure of this sort?

Mr. NOBLE. I should think that, with some allowance, it will give very reliable results.

Senator KITTREDGE. What allowance? You say, "With some allowance."

Mr. NOBLE. An allowance very much within the range of possible damage to the Gatun dam.

Senator KITTREDGE. Describe how you make your experiments with your filtration plant. Is not that all carefully placed?

Mr. NOBLE. I can give you results of some old experiments.

Senator KITTREDGE. You do not quite understand me, I think. I am quite willing to have you explain as much as you please, but what I am getting at is your comparison—

Senator HOPKINS. Let him answer this first. The evidence he proposes to give may be of interest in this connection.

(By request, the stenographer read the pending question of Senator Kittredge, as follows:)

"Senator KITTREDGE. Describe how you make your experiments with your filtration plant. Is not that all carefully placed?"

Mr. NOBLE. The experiment I am about to describe was made a good many years ago by some French engineers, when they took a 14-inch pipe and filled it at the bottom from 2 to 6 feet.

Senator KITTREDGE. That was placed by hand?

Mr. NOBLE. That was deposited, of course, by manual labor. There was no other way to get it in there. That experiment was repeated with sand of different degrees of fineness, some of it very coarse and some very fine.

Senator KITTREDGE. In what manner was that placed?

Mr. NOBLE. I can not say as to the precise method used, only it was put in by hand in that pipe, of course. That was subjected to heads running from 3 to 46 feet, and the amount of water passing through was very carefully determined. In a sand such as you would find in a bank you would be quite certain to have less permeability than in a carefully selected coarse sand—perhaps a washed and screened sand—and if you assume a medium sand, on the basis of these experiments, these results of d'Arcy and Dupuit, and apply to it a cross

section which would embrace the entire areas below elevation 150, which seems to be more than you are justified in assuming from the borings, the amount of water which would percolate through would be about $1\frac{1}{2}$ cubic feet per second, which is a very trifling amount in comparison with the amount of water stored in the reservoir; and the velocity of it through the sand, supposing that the water passages were one-third of the volume of the sand, would be about 5 feet in twenty-four hours. It is inconceivable, even allowing a very large margin, that that could carry out any material beneath a dam like Gatun.

Senator KITTREDGE. In your testimony four years ago you went at some length, as you may remember, into the manner of constructing the dam at Bohio, and the substance of your testimony at that time was that you would go down to solid rock; that is right?

Mr. NOBLE. I think that is right, without doubt.

Senator KITTREDGE. And you described the process by which that could be accomplished?

Mr. NOBLE. That was the plan of the Commission at the time.

Senator KITTREDGE. Did you not?

Mr. NOBLE. Yes; I presume so. I have not read my testimony recently, but I suppose that to be the case.

Senator KITTREDGE. Would you like to have me read it?

Mr. NOBLE. I accept your statement very gladly, Senator.

Senator KITTREDGE. And in that testimony you said that you would by pneumatic process go down to bed rock, which was 128 feet below the surface, and there put in your foundation construction to keep off this water. That is right, is it not?

Mr. NOBLE. I think that is undoubtedly so; yes, sir.

Senator KITTREDGE. And you have modified your views upon that subject since that time?

Mr. NOBLE. If we could put in, without going below 125 feet, a cut-off wall at Gatun, I rather think I would do it, though I think it would be a sentimental matter and rather an unnecessary one.

Senator KITTREDGE. Why would you do it, then?

Mr. NOBLE. I think most engineers would prefer a solid masonry dam—I will not say most engineers, because a good many prefer an earth dam; but my own preference would be, in a country, at least, where there are no earthquakes, a solid masonry dam and solid rock foundation, if you could choose the conditions to that end.

Senator KITTREDGE. Would you have any preference between that dam and a masonry core and an earth dam?

Mr. NOBLE. The masonry core dam is a matter the advisability of which is very much in dispute among engineers.

Senator KITTREDGE. But you would go to foundation if you could?

Mr. NOBLE. If we could reach rock by going to 128 feet, I think I would do it.

Senator KITTREDGE. At the Gatun dam site, if you could go to solid rock for your foundation of that dam, you would do so?

Mr. NOBLE. I think so; yes, sir.

Senator KITTREDGE. Why would you do it?

Mr. NOBLE. Mainly for the sentimental reason, to give to Congress and to the people a structure more in accordance, perhaps, with what they thought was right. I do believe, notwithstanding that, that the

Gatun dam will absolutely maintain the summit level of the Panama Canal with entire safety.

Senator KITTREDGE. But there are engineers who differ with you on that question?

Mr. NOBLE. Without doubt.

Senator KITTREDGE. Strongly?

Mr. NOBLE. Yes.

Senator KITTREDGE. And entirely?

Mr. NOBLE. Yes.

Senator HOPKINS. You said "entirely." I do not understand that. Mr. Parsons, who testified here yesterday, stated that that dam would answer the purpose. Do you know of any eminent engineer that differs entirely on that proposition?

Mr. NOBLE. I understand Professor Burr to do so.

Senator HOPKINS. Professor Burr?

Mr. NOBLE. Yes. It was Professor Burr's opinion that I had in mind when I made that answer.

Senator KITTREDGE. You have read his testimony?

Mr. NOBLE. Yes. I understand his testimony to be to that effect.

Senator HOPKINS. Do you know of any other eminent engineer that takes the radical view that Professor Burr does on that Gatun dam?

Mr. NOBLE. No; I do not recall any.

Senator KITTREDGE. Do you remember your testimony four years ago upon the question of the general character of conditions underlying the Chagres Valley?

Mr. NOBLE. No; I do not recall it.

Senator KITTREDGE (reading):

"Senator HANNA. I was asking you some questions with reference to the testimony furnished by Mr. Menocal. He was asked a question about the condition of the territory which would be covered by the Bohio dam, as to the permeable material. He testified as follows:

"Mr. MENOCAL. My impression is that the whole valley is permeable, more or less—the bottom of the Chagres, the flood valley.

"Senator HARRIS. You do not think it is covered by a sufficiently heavy and tight blanket—I believe that is the technical expression?

"Mr. MENOCAL. That is the proper expression. I do not believe that it is sufficiently covered in that way. The description of the valley by the Commission shows that it is composed of gravel, sand, clay, and other permeable materials mixed in various proportions.

"Senator HARRIS. The Commission's report also indicates that they recognize the existence of this permeable material.

"Mr. MENOCAL. Yes; but even this top blanket, I think, is permeable as well, in the greater part of it, if not at all points."

Did the Commission of which you were a member recognize the character of the material in the Chagres Valley as of the character indicated in this testimony that I have read?

Mr. NOBLE. Substantially so, I think, Senator. The bed of the Chagres from Bohio up is usually sand and gravel. There is a great deal of gravelly material in it, and the banks are usually of clay, and in a good many cases the clay is underlaid by some ancient bed of the Chagres. And you will find, on going through the clay, gravel below it. Those opinions expressed four or five years ago relate to the Chagres from Bohio up, where it was in sight and

where that was in question. In the immediate vicinity of Bohio we had found that, in one or two places at any rate, the borings, instead of passing through a top clay as they did in most places, which would be considered a blanket, went into the gravel without any intervening clay; that is, the gravel was in communication with the Chagres River at no very great distance. I think that should be understood as relating to the river in the neighborhood of Bohio and from there upstream. The Gatun section was not then under consideration, as nobody thought of building a dam there.

Senator KITTREDGE. Where does the water passing at the bottom of the Chagres River at Bohio pass with reference to the dam at Gatun?

Mr. NOBLE. The water in the underlying material?

Senator KITTREDGE. Where you strike the water after making borings at Bohio, where does it go to?

Mr. NOBLE. Oh, I do not know.

Senator KITTREDGE. Does it come out into the river before you reach Gatun?

Mr. NOBLE. I do not think anybody can say.

Senator KITTREDGE. And you do not know the conditions under the Gatun site, below the indurated clay, do you?

Mr. NOBLE. Certainly not.

Senator KITTREDGE. Is there anything by which we can determine the character of the material through which that water passes, if it does pass between the indurated clay and the rock?

Mr. NOBLE. I do not think there is the least ground to assume that there is any gravel between the clay and the rock, or that there is any water present in the indurated clay.

Senator KITTREDGE. Can you say that there is not any?

Mr. NOBLE. No; I think there is no ground for assuming that.

Senator KITTREDGE. Can you say that there is not?

Mr. NOBLE. Certainly not.

Senator KITTREDGE. You answered the question upon this subject four years ago—

Senator HOPKINS. Before you go on, where he says there is no ground for assuming that, I wish he would give his reasons.

Senator KITTREDGE. Certainly, if you desire.

Senator HOPKINS. You stated, Mr. Noble, in answering Senator Kittredge's question, that there was no ground for assuming that there was any water, or whatever it was, below there. Give your reasons.

Mr. NOBLE. It would be, to my mind, such an improbable case that it would require pretty strong evidence in the way of facts to demonstrate it.

Senator HOPKINS. I did not mean to interrupt you, Senator, but I thought he had better give his reasons.

Senator KITTREDGE. That is all right.

In answer to the questions of Senator Hanna regarding the character of the sand and gravel you said [reading]:

"If that soil extended down to bed rock, an earth dam would accomplish the entire purpose of maintaining the level of Lake Bohio, but the clay is underlaid by sand and gravel, the exact coarseness of which we do not know."

Why was it impossible for you to determine that?

Mr. NOBLE. It was very difficult to determine that, with any degree of certainty, by boring, Senator. You take borings, for example, with a 24-inch pipe, and put a smaller pipe inside to wash out the material, and you collect samples of the sand and gravel and dirt and so on as it comes out; but there may be coarser material down there that would not go up in the opening between the two pipes, or possibly material that would not go up in the larger pipe; so that it is impossible, without seeing the material actually on a larger scale than in that way, to determine precisely what it is.

Senator KITTREDGE. Was that done at Gatun?

Mr. NOBLE. No, sir.

Senator KITTREDGE. How can you tell us, then, the character of the sand and gravel that is known and conceded to be under that foundation?

Mr. NOBLE. There may be coarser gravel than has been shown by the samples. There can be no question about that. The existence of a percentage of coarse gravel, or gravel of any size, would not necessarily increase the permeability of that material. It may, in fact, decrease it. If you have a mixed material, coarse and fine, it is less permeable by far than a material of much less average coarseness all of one size.

Senator KITTREDGE. Can you tell us that it would?

Mr. NOBLE. Yes; I think that Mr. Stearns will give details of that to-morrow.

Senator KITTREDGE. Can you tell us?

Mr. NOBLE. No; I have not made the experiments, Senator.

Senator KITTREDGE. There is no question but that sand and gravel and decayed timber and all sorts of material are to be found under this location of the Gatun dam site. That is right, is it not?

Mr. NOBLE. The borings indicate that, without any doubt. The existence of decayed timber is not very disturbing, because that would indicate that there was no very strong current at the time that was dropped there. That would be, as far as it went, an indication that the current was in a condition to drop fine material rather than to carry it away.

Senator HOPKINS. To go back to the Gatun dam and the locks there: Have you, during the lunch hour, investigated the maps and drawings of the Commission, so that you can state with any clearness or definiteness as to whether, by changing the location of those locks, you can have a three-lock system, as is proposed in this plan recommended to Congress?

Mr. NOBLE. The topography there is not in sufficient detail to lay out on the map a site for three locks, and there are no borings elsewhere. Both of those are necessary to give a positive answer to that. The borings at Gatun have been extended for a sufficient distance to cover a site for two locks, but not enough to cover a site for three.

Senator HOPKINS. Two locks of what dimensions?

Mr. NOBLE. Nine hundred feet usable length.

Senator HOPKINS. If the two-lock system should be adopted instead of the three-lock system, as recommended by the committee, that would necessitate a higher lift than was proposed in the three-lock system?

Mr. NOBLE. If the entire lift were made at Gatun.

Senator HOPKINS. Yes. Well, what other suggestion have you made in that direction?

Mr. NOBLE. The plan of having a lift of two locks at Gatun of about 30 feet each—and I shall ask General Davis to correct me if I am wrong about this—and a final lift at Bohio, as advocated by General Abbott. The matter has been under some discussion.

Senator HOPKINS. That plan is entirely feasible, too, is it?

Mr. NOBLE. Oh, yes.

Senator HOPKINS. Something was said before lunch about a lift of 42½ feet if the entire lift of 85 feet is to be at the Gatun dam. Is there anything in that that would be dangerous?

Mr. NOBLE. I think not. The lock construction and the gate construction is just as safe as for any other lift, provided they are properly designed. If it should occur that a boat should drive through the head of the lock I do not think there would be very much left of it on a lift of 30 feet, but one of 40 feet, of course, would be more severe.

Senator HOPKINS. Something was said by one of the witnesses with reference to the danger of a lock canal to vessels in going in and out of the locks. Have you had any experience or observation that will enable you to give us any news as to the character of that danger and the extent of it?

Mr. NOBLE. I was at the St. Marys Falls Canal for about twelve years in local charge of the work of improvement there. During the last year I was the superintendent of the canal for operation, also. I observed closely all that was going on during the entire twelve years, and there was never any serious accident at the gates or to the lock in any way caused by the movement of vessels.

Senator HOPKINS. Well, do you, from your experience, regard the construction of a two or three lock system at Gatun as being at all dangerous to navigation?

Mr. NOBLE. I think the danger is inappreciable. I base that upon the experience had at the Soo for more than fifty years, where no serious injury has ever been done to a ship at the lock.

Senator HOPKINS. The witness who was here yesterday, Mr. Parsons, I think spoke about some accidents at Manchester.

Senator DRYDEN. When the lock was absolutely crushed down, broken down.

Senator HOPKINS. Under what conditions could such an accident as that occur?

Mr. NOBLE. The locks at Manchester are not provided with suitable approach walls, and vessels are not under control by lines until they get to the lock itself. That is my recollection of all the locks, and I have examined the drawings of the Manchester Canal since this discussion was commenced, and they conform to that. At the St. Marys Falls Canal there are long vertical walls leading to every lock, and at the upstream end those walls are more than a mile in length and at the downstream end perhaps they are 2,000 feet in length.

Vessels come to a stop, or at least come to a very slow movement, and before they are allowed to approach the locks they are required to have out a number of lines which lock tenders carry from snubbing post to snubbing post, ready to put them on at any time. Those facilities and those approach walls are very essential for the

safe navigation of a canal. I do not believe that if they had had them provided at Manchester those accidents would have occurred.

At the Kiel Canal they have a floating platform attached to mooring piles that is very much inferior to an approach wall. If a vessel touches them and then heels over a bit they are apt to roll over. They have that same appliance at the Canadian canal, Sault Ste. Marie, where, for the whole length of the canal itself, not immediately at the locks, the rock is left somewhat rough; and in order to protect vessels they have a timber fender alongside which now and then gets rolled over.

I think with suitable approach walls so that vessels can be brought under control or stopped if necessary or thought advisable, before they get to a lock, the dangers are rendered very small indeed. Then, by the provision of the additional gates, which the minority report suggests, so that there will always be two pairs closed against an approaching ship from the upper level, there does not seem to be enough risk left for the liveliest imagination to make anything out of. That seems to be so absolutely demonstrated by the fifty years' experience at the Soo that I hardly see how it could be questioned.

Senator HOPKINS. Then you attribute this damage at Manchester to the fact that the locks were not up to date?

Mr. NOBLE. I think so. The locks themselves are fine pieces of mechanism. In all the European canals that I have seen the masonry and the lock machinery are very, very fine; but they seem to have that fatal defect.

Senator HOPKINS. Yes. So that in making the recommendation that was made by the minority for the three-lock system here the engineers who joined in that took into consideration all of the elements of danger that could be imagined in the construction of a canal of that kind?

Mr. NOBLE. Yes, sir; all the elements of danger that had been suggested by the various members of the board were given very careful attention.

Senator HOPKINS. And in the judgment of the men who joined in the minority report it was so infinitesimal in character that they did not regard it as of any consequence?

Mr. NOBLE. Yes. That opinion is expressed very clearly, I think, in the minority report, in which we all agreed without any qualification.

Senator HOPKINS. Now, I wish, Mr. Noble, that you would go on in your own way and give the points of superiority of the plan suggested by the minority over the sea-level canal.

Mr. NOBLE. The reason why the minority believe the lock canal to be superior to the sea level are given at the beginning of the minority report, substantially.

The first one was that the lock canal would have a greater capacity for traffic than that afforded by the narrow waterways proposed by the Board.

The ground for that is indicated by the calculated time required for transit across the Isthmus, on page 86 of the report, which shows a very rapid increase in time required to pass as the traffic increases; and we believe that before a great while after the completion of the canal—at any rate, before the traffic becomes very heavy—there

would be at the Isthmus, as there is everywhere in the United States in narrow channels, a strong demand for the widening. That is the universal experience in every waterway, I think, in the United States. That feature of it is given somewhat in detail in one of the appendixes, where the successive stages of increasing the width and channels of the Great Lakes is dealt with.

The next reason was that we believed that the ships would pass through the lock canal with less danger to themselves and less danger of interrupting traffic. While recognizing that the locks themselves were a feature that we would gladly dispense with if other things were equal, the advantages of the broad navigation seemed to greatly outweigh the disadvantages attending the use of locks. The broader channels could not be interrupted by the sinking of a single boat, because there was so much room there, and there would be less danger of a ship colliding with the sides.

The sea-level canal has quite a length between Bohio and Obispo of narrow channel with rock not reaching to the top of the water, but still submerged; and I regard that, as the minority regarded it, as the most dangerous kind of a channel for a ship to traverse. If the vertical walls could be extended to the water line, it would be quite a different matter.

Senator HOPKINS. Just explain that fully, so that a layman may understand it without much reasoning on his own part.

Mr. NOBLE. A large vessel does not have a great deal of leeway on either side in a channel 200 feet wide. It will try to follow the center line very closely, but if by any want of judgment in steering or by the effect of a cross-wind or anything like that it does come in contact with the sides, in such a case as that the sharp rock strikes the boat in its weakest point—under water—which would almost inevitably cut a hole in the hull. At Suez they have a rock section, and they do not allow any meetings of any kind in that section. They regard it as their least safe section.

In the old days at Sault Ste. Marie, in the canal constructed by the State, the cutting was partly in rock, and near the head of the canal wholly in rock, and that was a fruitful source of injuries to ships; the bilge of the ship running upon those slopes and the hull getting into contact with those sharp points caused a great many accidents. The accidents in the canal were in the waterway and not at the locks in those days. When the improvements of the canal were taken in hand by the General Government the first improvement that the vessel interests demanded was to take out those slopes and put in vertical sides, and that was done. That work was completed in about 1874. Since that time there has been no trouble of that sort there.

Senator KITTREDGE. Under whose supervision was that work done?

Mr. NOBLE. I was the local engineer, Senator.

Senator KITTREDGE. I mean, was it done under the supervision of the State or the nation?

Mr. NOBLE. The nation.

Senator KITTREDGE. In what year?

Mr. NOBLE. In 1874. The removal of these slopes, the improvement of the work was begun by the United States in 1870; there was some deepening of the canal, but in the work done by the United

States agents the thing that they gave preference to was the taking out of the slopes.

Senator KITTREDGE. The United States Government did not take over that work until 1882, did it?

Mr. NOBLE. Not for operation. I think it was in the spring of 1881. I took over the operating when it was first turned over to the General Government. I am not quite certain as to the year.

Senator KITTREDGE. The Government did work prior to that time?

Mr. NOBLE. Oh, yes, sir; the canal was operated by the State and tolls were collected by the State during that whole time, and the expense of the improvement was paid by the General Government.

Senator DRYDEN. If these walls were vertical instead of slanting, would not that danger be obviated largely?

Mr. NOBLE. If they could be extended up to the water's surface, so that there would be no sharp corners for the hull of the boat to strike. In the Culebra cut the committee may remember that the Isthmian Canal Commission provided for a revetment wall the whole length in their estimates with that thought in view, that there must be a smooth side in the narrow channel for the safety of the ship.

Senator DRYDEN. Is it impracticable to make these walls vertical?

Mr. NOBLE. In the material there?

Senator DRYDEN. Yes.

Mr. NOBLE. It seems to be the opinion now that that is not necessary everywhere anyway, but that it would be impossible to determine how much revetment will be required to secure a smooth vertical side except as the work goes on.

Senator HOPKINS. That would be obviated in a lock-level canal?

Mr. NOBLE. In a lock-level canal there would be a narrow section of only about 4 miles instead of 19, and they intend there to have vertical walls by revetment, if necessary, extending above the water surface.

Senator HOPKINS. If we could have a sea-level canal, and follow the same caution that has been observed in the Suez Canal for a distance of 19 miles, that would not allow vessels to pass each other?

Mr. NOBLE. No, sir; I do not think that protection could be really carried out.

Senator HOPKINS. Go on with your analysis of the two schemes or types of canal.

Mr. NOBLE. The third point is the quicker passage across the Isthmus for large ships or large traffic. I went into that pretty fully this morning.

Senator HOPKINS. Then pass on to the next.

Mr. NOBLE. The fourth point was the materially less time required for construction. We believe that the period of nine years for a lock-level canal is far more conservative than the period of fifteen years for a sea-level canal, so that I think there is at least six years advantage in point of time for the lock-canal construction.

The fifth point was the materially less cost, which goes, I think, without much discussion. It amounts to somewhere in the neighborhood of \$100,000,000.

Senator DRYDEN. On the question of cost, Mr. Noble, it has been testified by one of the witnesses—Mr. Burr, I think—that the submerging of this vast extent of land would involve the Government in an enormous expense, running up to something over \$18,000,000 he calculated, putting the price of the land at what he thought was a

conservative estimate in comparison with prices at which some lands are already held. Have you given thought to that phase of it?

Mr. NOBLE. It has been rather difficult for me to conceive of the United States being held up by anybody on the Isthmus to the extent of \$18,000,000. The land is not worth it. It is worthless, or practically worthless. There is a little banana land, I believe, that has value. General Davis, I think, will confirm me that it is worth about \$50 an acre; that it costs pretty near that to develop it, and when it is ready it is, of course, worth that; but that is very small in amount, and the rest of the land that you would have to acquire is practically wild land, most of it swamp.

Senator HOPKINS. And worthless for all practical purposes?

Mr. NOBLE. Yes, sir; unoccupied.

Senator HOPKINS. Then you do not agree with the statement of the witness that it would require any such sum of money to acquire the land necessary to have a lock-level canal?

Mr. NOBLE. No, no; I do not think so.

The capacity of the locks for passing ships has been discussed here a good deal.

Senator HOPKINS. Yes.

Mr. NOBLE. The minority give the facts as ascertained at the Soo. Do you want that?

Senator HOPKINS. I should be very glad to have you develop that.

Senator KITTREDGE. I did not understand where you said the experience was taken from.

Mr. NOBLE. At the St. Marys Falls Canal. The ships passing through the St. Marys Falls Canal are of far greater average size than those passing through any other ship canal in the world, I think. The report of the minority shows that.

If I remember the figures correctly, they are about 15 or 16 times as large as the ships going through the Kiel Canal, and something like five or six times as large as those going through the Manchester Canal; so that, although there is no salt water in it, it is really a ship canal, and the experience gained there is strictly pertinent to the Panama Canal. There are vessels up there reaching a very considerable size. There are a good many in use now, quite a number that are more than 500 feet long and upward of 50 feet beam. And there are some being built this winter 600 feet long by 60 feet or a little more beam.

Senator HOPKINS. That is longer than any vessel that goes through the Suez Canal, is it not?

Mr. NOBLE. I think it is. I am not perfectly certain.

Senator HOPKINS. I think you said 550 feet, General?

General DAVIS. I have not those figures with me to-day, but the longest of those ships that I gave you a memorandum respecting the other day I think was about 500 feet—the battle ships.

Mr. NOBLE. The traffic passed through the Poe lock for some months last year at the Sault Ste. Marie, a single lock 800 feet by 100 feet, was at the rate of 40,000,000 tons a year. That is through one lock. At Panama you have two locks, and instead of eight months' navigation you have twelve months, although you can reduce that a little bit for short periods for repairs, if you will. The estimate that we give of 80,000,000 tons seems to be absolutely justified by the facts.

We found that the amount of traffic that a lock will pass depends very largely upon the size of the lock.

The Wetzel lock, for example, the one second in size at the Sault Ste. Marie, passed in 1895, when it was hard pushed—it was the only lock during the greater part of the year that was available for vessels—about 15,500,000 registered tons; and the Poe lock in 1905, a larger lock, without being pushed at all, passed 24,000,000 registered tons. So that its capacity is certainly 60 per cent more than the Wetzel lock, and probably very nearly double. Now, the locks at Panama, 900 feet by 95 feet, are larger in area, and the draft of ships passing through will certainly exceed the maximum of 19 feet and some inches through the Soo; and that will all tend to increase the traffic capacity of the locks. I can not doubt for a moment that the estimate of 80,000,000 tons per year for a duplicate system of locks is moderate.

Senator KITTREDGE. What was the tonnage passing the Soo last year? We have discussed that question.

Mr. NOBLE. I do not think I have it here, but it is approximately 36,000,000 registered tons and, I think, about 45,000,000 tons of freight.

Senator KITTREDGE. Last year?

Mr. NOBLE. Yes. That is subject to correction, Senator. That is my best recollection. I have not the exact figures with me.

Senator KITTREDGE. It varied, as I recollect, from 36,000,000 to 40,000,000 tons.—

Mr. NOBLE. I think it is about 45,000,000 tons freight.

Senator HOPKINS. What is the time required to pass the lock here at the Soo?

Mr. NOBLE. The time given in the records at the Soo includes the time to pass through the canal itself. The extreme length is about $1\frac{1}{2}$ miles. The average for last year was one hour and thirty-nine minutes. That time is made up of several elements; one of them, of course, is the time for lockage, and the lockages at the Soo were mostly fleet lockages, so that the first boat, after entering the lock, has to wait until the second one can be placed, which tends to increase the time for the first vessel at least. Then, all the time necessary to navigate the canal also is included. In the month of December the entire period was fifty-five minutes. In the month of April it was two hours and fifty-nine minutes. Why those differences occur I can not say.

Senator HOPKINS. Take a fleet of six ships here at the Gatun locks, and how long, in your opinion, would it take those six ships, say, 500 feet in length, to pass through the locks, supposing that they came up about the same time and were anxious to get through the locks?

Mr. NOBLE. If I remember rightly, we figured the interval between ships as something like fifty minutes. That was up here the other day. Then, we made an allowance for delays of all kinds, such as based upon the Soo Canal experience, of approximately 50 per cent. That would give about seventy-five minutes.

Senator DRYDEN. This morning, in answer to a question, Mr. Noble, I understood you to say that as to the speed of getting through the lock canal, the capacity of the canal was the capacity of the locks. That would be true only in a restricted sense, would it not? That is

to say, just as soon as a boat was through the locks, then it would speed away at a rapid rate of speed and overcome any loss of time after it got through the locks? The delay, in other words, would only be regulated by the time it took the boat to get through the locks, would it not?

Mr. NOBLE. I did not understand the question to cover that. What I understood you to mean was the maximum number of ships that could pass through the lock canal in a given period, say a week or a month or whatever it might be. That would be limited by the number of boats that could be gotten through the locks, because as soon as they would pass through the locks they would go through the intervening waters very quickly. In fact, the capacity would be regulated practically by the first lock they came to. That would certainly be the case if there were duplicate or triplicate locks, because the first lock encountered would space the boats, and they would go right along and find the next lock awaiting them without any appreciable further delay.

Senator DRYDEN. But in comparing the relative time in which the boat could get through a lock canal with that in which it could get through a sea-level canal, the speed attained in the lock canal would not be regulated by the locks any further than the time it took to go through the locks?

Mr. NOBLE. No; not at all.

Senator DRYDEN. No. I wanted that made right on the record, as I thought possibly it might be misunderstood by anyone reading the record.

Senator KITTREDGE. I suppose, in speaking of the capacity of the canal being limited by the capacity of the locks, you meant the tonnage?

Mr. NOBLE. The tonnage capacity in a given time; yes.

Senator KITTREDGE. I assumed that that was it.

Mr. NOBLE. That was the thought I had in mind.

Senator KITTREDGE. In other words, you can not pass through the canal any more tonnage than you can get through the locks?

Mr. NOBLE. Precisely; because you can not get to the higher levels of the canal.

Senator KITTREDGE. That is the proposition, of course.

Senator DRYDEN. When you designed these locks and provided for a usable space of 900 feet, you assumed that there was to be but one set of gates at each end of the locks, I suppose. That was your assumption—that there would be but one set of gates?

Mr. NOBLE. Yes.

Senator DRYDEN. It seems that the reduction in the usable lengths of those locks has been brought about by the provision for a second set of gates at each end. You so understand that, do you, Mr. Noble?

Mr. NOBLE. No; I thought that the point raised this morning was due to a draftsman's mistake.

Senator DRYDEN. No; it was testified yesterday by Mr. Parsons that the reduction in the usable length of the locks was brought about in that way—by a subsequent conclusion of the minority that it was a matter of safety and was a protection which they thought necessary to put up, to establish another set of gates at each end of the lock, so, as I understand it as a layman, that if there should be an accident,

a boat coming up against the gates and smashing one set of gates would still have another set of gates to protect it.

Mr. NOBLE. I think I see your point now, Senator. With a ship 900 feet long coming down stream in the summit level, the lock gates and safety gates at the lower end of the upper lock being closed in front of it, its stern would not clear the upper-lock gates; but the safety gates just beyond them would be closed. The safety gates at the lower end of the lock would be opened, the summit level after this operation being still protected by two pairs of gates, viz, the safety gates at the head of the upper lock and the lock gates at the foot of the same. The ships would then be moved toward the lower-lock gate until the available distance was taken up, and then the lock gates at the upper end of the lock would be closed. The operation of locking down through the flight of locks would then be continued in the ordinary way. In the operation just outlined, the summit level would always be protected by at least two pairs of gates and the lock would have a usable length of 900 feet under all circumstances.

Senator DRYDEN. Have you given any thought to the question of how we would protect or defend this canal in time of war?

Mr. NOBLE. No, sir; I have not looked at the military situation at all.

Senator DRYDEN. But the question has arisen as to whether these locks could not be attacked with great ease, even under the most thorough guarding on the part of the Government.

Mr. Parsons stated that a single man could carry enough dynamite to those locks or into those locks, and might do it on a merchantman, for instance, and carry this dynamite in sufficient quantities to blow the locks all to pieces and destroy them.

Mr. NOBLE. The amount of that danger, I think is indicated by the fact that in the history of canal navigation that thing has never been done. It is a conceivable possibility, but we have to consider the probabilities in a matter of that sort.

Senator DRYDEN. Of course the point came up in connection with whether the lock system could be much more easily destroyed than the sea-level system.

Mr. NOBLE. Yes. The minority thought that the difference in risk of the stoppage of navigation as between the two systems was not very much. A single vessel would block the sea-level canal to a certainty, and it probably would not block the channel of the lock canal, while the locks themselves are the points which certainly would be most carefully and could be most easily guarded. It would be almost impossible to guard every foot of the sea-level canal across the Isthmus. There are a good many points where it touches on the jungle; but the locks are the places where defense would be readily provided and would be most thoroughly done.

Senator DRYDEN. The statement made by Mr. Parsons yesterday was to me startling as to the possibility of these locks being destroyed. You have already touched upon that, and I do not know that you want to say anything more; but he made the statement that, in his judgment, as I remember it, there was not any question about the danger or liability of these locks being utterly destroyed, broken down, crushed, so that it would take from three to five years to restore them.

Mr. NOBLE. It seems inconceivable that the locks would be destroyed. A gate might be disabled without using a very large quantity of dynamite; but to destroy the lock you would have to have something like a steamboat loaded with it. That is all conceivable, but practically I do not think it amounts to anything.

Senator DRYDEN. You refer to the gates?

Mr. NOBLE. Yes.

Senator DRYDEN. Which are, of course, a part of the locks?

Mr. NOBLE. Yes.

Senator DRYDEN. This statement of Mr. Parsons applies to destruction caused by large steamers meeting with an accident there, as well as by dynamite.

Mr. NOBLE. Oh, yes. Well, do you mean doing it maliciously?

Senator DRYDEN. Oh, no; not in the case of the steamers; that being a pure accident.

Mr. NOBLE. Oh, yes.

Senator DRYDEN. The question was asked, I think by myself, as to what would be likely to become of the boat that should meet with such an accident there, and in general his reply was that probably the fragments would be found out in the Caribbean Sea.

Mr. NOBLE. Well, in the Manchester Canal I believe the boats stopped in the lock; but these lifts are higher, and I should think it quite possible that they would go right along. I think that the danger is small. It has not occurred for fifty years at the Soo, although a boat ran into the lower gate of the Poe lock—I think that occurred twice—without stopping the navigation very much. At the Poe lock they have two pairs of gates at the lower end of the lock; and on one of those occasions they simply used the next pair for the remainder of the season. They did not stop to repair the first pair.

Senator DRYDEN. Have you found that the mechanism in use in these locks is so simple and so strong that it does not get out of order, so that it is safe from the objection of liability of getting out of order?

Mr. NOBLE. As to the machinery for the Wetzel lock I do not think that was ever out of order for a quarter of a day a year during the season of navigation. There are little things that occur in the operation of a lock—a rope fender may get between the gate and the sill and we would have to stop and open the gate and fish it out; or a piece of driftwood may get in there. Those things occur sometimes, but they do not count much in the aggregate.

At Liverpool they have machinery somewhat like that we have at the Soo or at the Wetzell lock. Perhaps I should reverse that statement and say that ours is similar to theirs; and they work very safely, without trouble.

In the Poe lock at the Soo, the last one built, the machinery gave considerable trouble for two years, until it was overhauled and rebuilt. That runs along very smoothly now. That was on quite a different plan from the other. So that the best type of machinery in use for operating lock gates does not give trouble. It is very simple and reliable.

Senator HOPKINS. After a vessel gets in the lock, there is not very much danger of that vessel running up against the gate and knocking the gate out, is there?

Mr. NOBLE. We have had fifty years of immunity from that at the Soo, Senator.

Senator HOPKINS. In the construction of the Gatun lock, the system of construction, in your judgment, would be as safe as the one at the Soo?

Mr. NOBLE. It is safer, because we have these additional safety gates at both ends of the summit lock. That is the only place where any serious trouble could occur, and provisions are made in this plan here unprecedented in point of avoiding danger.

Senator HOPKINS. I think that is all.

Senator TALIAFERRO. Were these safety gates you speak of provided for in the original plan of the minority, Mr. Noble?

Mr. NOBLE. Yes, sir.

Senator TALIAFERRO. Is the plan as proposed by the minority one that could be recommended by this committee without modification or change?

Mr. NOBLE. Unquestionably, I think.

Senator TALIAFERRO. There is no change necessary at the locks on the Atlantic side?

Mr. NOBLE. I think not. I think you must leave a little leeway to the constructing engineers to make such minor changes as may be necessary as the work goes on—the revetment of the Culebra cut, and all that—and possibly this alternative between two locks and three at Gatun, although I have not the slightest doubt that they can get a satisfactory site for three locks at Gatun.

I am far from apprehending that we have not got a suitable place now, only they may have to move the locks a little farther down stream; but, as I suggested before, that is not proven by the borings. A little supervision of changes in location ought to be left to the judgment of the constructing people.

Senator TALIAFERRO. So that you consider that this flight of three locks could be put in now as proposed by the minority?

Mr. NOBLE. I believe so, if you will only leave a little leeway as to the location, Senator.

Senator TALIAFERRO. Mr. Noble, if it had transpired that the sea-level canal could have been built for the amount of money and within the time that the lock canal could be built, would you have joined in the minority report for a lock canal?

Mr. NOBLE. I do not know. I should want to think that over pretty carefully. A broad sea-level canal, say, 500 feet wide—I say 500 feet wide for illustration—of course would be preferable, in my opinion, to any lock canal; but it would be so enormously costly that I doubt if the committee would consider it seriously. If you could build a sea-level canal for the same money, the greater facility it offers for indefinite widening and for ultimately becoming what our friend, Bunau-Varilla, calls the Straits of Panama, would be quite a strong feature in its favor.

Senator TALIAFERRO. Could this sea-level canal, as proposed by the Board of Consulting Engineers, be widened as necessary without very serious cost?

Mr. NOBLE. The sea-level canal?

Senator TALIAFERRO. Yes.

Mr. NOBLE. It would cost a good deal of money to widen that. The

report of the minority contains a figure, which I do not recall now, giving that.

Senator TALIAFERRO. Could it not be widened without very serious cost at all points except through this rock cutting in the Culebra cut?

Mr. NOBLE. It would be a matter of relatively inexpensive dredging until you got to the rock sections. The rock sections extend a pretty large part of the way from Bohio to the Pacific. It is a long distance.

Senator TALIAFERRO. Eliminating, then, the difference in cost and the time of construction, you are not prepared to state whether you would prefer the lock canal or the sea-level canal as proposed by the Board?

Mr. NOBLE. I would not be prepared to give a definite opinion on that without careful study. The premises themselves are inconceivable, I think, if I may be permitted to say so, and the matter has never presented itself to my mind before.

Senator TALIAFERRO. I ask the question, Mr. Noble, because I wanted to ascertain how much stress you put upon the difference in cost and the difference in time in selecting and reporting in favor of this high-level canal rather than in favor of the sea-level canal.

Mr. NOBLE. I should not consider the sea-level canal, as it is now proposed to be built, to be as good as the lock canal as now proposed to be built, but the possibilities of future enlargement—and, on the premises you were proposing, it would then become, of course, economical enlargement—would be a very attractive feature of that project.

Senator TALIAFERRO. Have you ever considered the possibilities of converting this lock canal into a sea-level canal later on?

Mr. NOBLE. Oh, yes, sir.

Senator TALIAFERRO. Do you agree in the estimate of cost of \$280,000,000 to do that work?

Mr. NOBLE. I agree in that if the work of transformation is to be done in the near future. I should rather expect, if it should be deferred for a long time, that processes would be developed that would result in more economical transformation. But as the matter was presented to us, obviously for immediate transformation, I think that the Board were unanimous on the subject, with possibly one exception, that the estimate would be correct—that the prices used were about as low as it was safe to present.

Senator TALIAFERRO. You agreed with the Board in the estimate of cost of the sea-level canal?

Mr. NOBLE. Oh, substantially; yes.

Senator TALIAFERRO. The material difference between you was as to the time necessary to construct the sea-level canal?

Mr. NOBLE. Yes.

Senator TALIAFERRO. Do you regard, other things being equal, the sea-level canal as the ideal canal?

Mr. NOBLE. If you make it as broad as the lock canal, certainly; if you make it as broad and do it as cheaply.

Senator TALIAFERRO. You consider the principle of the sea-level canal the ideal principle for canal building?

Mr. NOBLE. Oh, certainly. I think that locks themselves are objectionable, other things being equal.

Senator TALIAFERRO. I have no further questions.

Senator HOPKINS. I understand you to say, Mr. Noble, that taking the sea-level canal as proposed by the majority and the lock-level canal as proposed by the engineers with whom you joined, that the lock-level canal as proposed would be the better canal?

Mr. NOBLE. It would be the better canal if both were built exactly according to the designs presented to the committee.

Senator TALIAFERRO. Mr. Chairman, I did not understand the witness to make as broad a statement as that.

Senator HOPKINS. He is making the statement now.

Senator TALIAFERRO. I wish to call to the witness's attention what his statement was a moment ago—that the questions of cost and of time entered into the consideration.

Senator HOPKINS. Yes; you brought that out; but in answering I understood the witness to say—and if I did not understand him correctly he can correct me—that taking the sea-level canal as proposed by one set of engineers and the lock-level canal as proposed by the other, he would prefer the lock-level canal, regardless of time or money.

Mr. NOBLE. I think the lock-level canal as presented to this committee is a better canal than the sea-level canal as presented to this committee.

Senator HOPKINS. Yes; that was the point that I was getting at.

Senator TALIAFERRO. Mr. Noble, that is in consideration, I understand, of the reasons which you have given in that minority report?

Mr. NOBLE. Yes.

Senator TALIAFERRO. Eliminating any of those reasons that you have assigned for your preference for the lock-level canal, would it change your conclusion?

Mr. NOBLE. What, for example, may I ask?

Senator TALIAFERRO. The time and cost.

Mr. NOBLE. Certainly; I think that the lock-level canal as planned is a better canal than the sea-level canal as planned—better for the use of commerce, without regard to cost.

Senator TALIAFERRO. If they cost the same?

Mr. NOBLE. If they cost the same. I think that if we had two canals on that route, if it were possible, one built as proposed by the lock-level people and the other built as proposed by the sea-level people, the lock canal when finished would be the better one.

The CHAIRMAN. Senator Morgan has sent me word that he has no questions to ask, and that he will not be in the committee room this afternoon.

Senator TALIAFERRO. Is there any further statement you would like to make to the committee, Mr. Noble, on your own account?

Mr. NOBLE. There are one or two points that I might possibly touch on without encroaching too much on the time of the committee.

Senator HOPKINS. We will be glad to hear you.

Mr. NOBLE. One is the matter of curvature. It was stated here, I think, in one of the hearings recently, that in the lock canal the curvature was as sharp as a radius of 1,700 feet.

I wanted to point out that the line as laid down by the lock committee is a succession of broad, straight reaches, and it is connected by turns similar to those which experience has shown to be advisable at Sault Ste. Marie, on the St. Marys River; and the vessels there

ordinarily turn pretty sharply in making these changes of direction. But there is no change of direction in the lock-level plan of the Panama Canal, where, if you lay down a curved channel 200 feet wide and of 8,000 feet radius, it will not fall wholly within the limits of the channel; so that if a vessel chose to go around that curve at an 8,000-foot radius it could do so. But as a matter of fact they would not do it.

I thought possibly that was necessary to straighten out the idea as to curvature.

Now, I think that the Mill River dam was cited here a day or two ago as an example of the unsafe construction of dams; and I have been at some pains to collect some data in regard to that dam. I have here a few notes which it will not take long to present to the committee.

The Mill River dam was built in about 1865, and it failed in 1874. It was a dam 40 feet high, and it had a core wall, and the core wall was supposed to be founded in hardpan. It was such a very serious disaster, and created so much engineering interest besides, that a committee was appointed by the American Society of Civil Engineers to report upon it. That committee was composed of James B. Francis, by all odds the most eminent hydraulic engineer of his day, and Messrs. Theodore G. Ellis and William E. Worthen, both of them very distinguished engineers.

They reported that the dam as planned was to have side slopes as steep as one in one and a half; that the core wall was to be founded by digging a little trench 2 or 3 feet deep in the hardpan; that the fill was to be made in thin layers within 5 feet only of the core wall, and outside of that material was to be dumped in in 5-foot layers without being compacted.

The construction was as bad as possible. It was built without adequate inspection, and there was reason to believe that the core wall in places did not extend even down to the hardpan; that it was not properly founded.

An observer, an eye-witness of the failure, said that the first thing that occurred apparently was the sloughing off of the material on the downstream side of the core wall.

Senator KITTREDGE. Do you mean of the earth?

Mr. NOBLE. Of the earth; yes; this illy compacted material; and that it was followed shortly after by another slide, and that that left the core wall—that thin core wall that was only 5 feet thick at the base—to support that entire head of water; and it naturally fell over, and the whole thing went out in a very few minutes.

The engineers criticised the construction as being entirely improper, on account of the material not having been put in in layers and made solid; the cross section was never large enough anyway, and the core wall itself was utterly inadequate.

I thought it was desirable to present those facts to the committee as giving sufficient reason why that particular earth dam failed. There were a number of reasons why it should have failed.

I do not think of anything else that I care to present to the committee.

Senator ANKENY. This is a timber country, Mr. Noble; and does not the water carry vast amounts of timber and debris down above your dams there?

Mr. NOBLE. I do not know how much timber those rivers carry. I never have happened to see them in flood. It is a timbered country, and I should rather expect that they carry timber.

Senator ANKENY. It is apparent that they do from the deposits of timber and other matters below there.

Mr. NOBLE. Oh, that does not necessarily mean that there was a great amount carried; but I should expect them to carry it.

Senator ANKENY. Following it further, will not that debris and sediment that collects above those dams eventually make a deposit there that will almost, in years, fill up the dam?

Mr. NOBLE. The lake itself, you know, will extend away up the Chagres, 10 or 12 miles above Gamboa.

Senator ANKENY. I have Johnstown in my mind; so you know what I am thinking of.

Mr. NOBLE. Yes. Now, the tributaries of the upper Chagres, where timber would mainly come from, I should think, would be impounded and become slack current, and that material, I think, would eventually go ashore. The winds would carry it across.

Senator ANKENY. Yes; but is not that a menace to your dam?

Mr. NOBLE. I think not. The wind there, fortunately, is almost invariably from the dam, toward the other side of the lake. The trade wind blows across there and blows from the dam into the interior. I should not expect any of it to ever reach the dam, but it might collect on the opposite shores.

Senator ANKENY. The sediment certainly will. That is what the dam is there to stop.

Mr. NOBLE. I do not think there will be much sediment in the water there, Senator. I think the sediment will be deposited long before it reaches the canal line.

Senator ANKENY. Where the current ceases?

Mr. NOBLE. Where the current ceases.

Senator ANKENY. That is all I have to ask.

The CHAIRMAN. Mr. Noble, we thank you for your presence here and will not need to trouble you further.

Mr. NOBLE. I am greatly obliged for the courtesy of the committee.

(The committee thereupon adjourned until to-morrow, Friday, March 16, 1906, at 10.30 o'clock a. m.)

STATEMENT OF FREDERIC P. STEARNS

**BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.**

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ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Friday, March 16, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Hopkins, Knox, Ankeny, Morgan, Taliaferro, and Simmons.

Present, also, Maj. Gen. George W. Davis, U. S. Army, retired.

STATEMENT OF FREDERIC P. STEARNS, ESQ.

The CHAIRMAN. Mr. Stearns, please state your full name, age, residence, and occupation.

Mr. STEARNS. Frederic P. Stearns, Boston, Mass.; age, 54; civil engineer.

The CHAIRMAN. And the position you are holding at the present time is what?

Mr. STEARNS. My regular position is chief engineer of the metropolitan water and sewerage board of Massachusetts.

The CHAIRMAN. Now, Mr. Stearns, if you will be kind enough to give us a little history of yourself, say for the past ten or fifteen years, stating the different positions you have held during that time, it will be a favor to the committee.

Mr. STEARNS. I have been engaged in engineering work for thirty-seven years. I was connected with the additional water supply of the city of Boston as a division engineer from 1872 to 1880, and there I had to do with the construction of waterworks and hydraulics, and especially of importance, possibly to you, hydraulic experiments, which were the basis of some publications on the subject before the American Society of Civil Engineers.

From 1883 to 1886 I was engaged upon the Boston main drainage works, the main sewerage system of the city of Boston, which included a large amount of heavy construction.

From 1886 until 1895 I was engineer of the Massachusetts board of health. That is practically a sanitary board in its engineering features, and I had occasion to look after the water supplies of the State of Massachusetts, and the experience there that is of especial value in connection with the Panama Canal was with reference to water supplies taken from the ground, and the filtration of sewage, the experience in both of those lines being of value as to the movement of water through the ground. I had occasion to determine the capacity of many ground-water supplies. Also, in connection with my experience there, I was engaged upon devising a system of metropolitan sewerage for Boston

and the surrounding towns, and later in devising a system of water supply for Boston and its suburbs at an estimated cost of \$24,000,000.

From 1895 up to the present time I have been the chief engineer of the metropolitan water and sewerage board, engaged in constructing the works at a cost of about \$24,000,000, and in connection with that work I have had occasion to build many dams, one of them a masonry dam that has a head from bed rock up to the water line of the reservoir of 189 feet. I also have constructed there what is known as the north dike of the Wachusett reservoir, which is similar to the Gatun dam.

While I was with the State board of health a great many experiments upon filtration of sewage were carried on, and, although not immediately under my direction, a Mr. Allen Hazen, who is now known as a distinguished engineer, chemist, and physicist, made experiments to determine the resistance of sands and earths of various kinds to the filtration of water. One of his recent engagements was as consulting engineer in charge of the water-filtration plant here for Washington. It was on the basis of the work that he did and of which he published the results that I designed the dam upon the metropolitan waterworks that is almost exactly like this proposed Gatun dam. Before constructing that dam, however, I carried on experiments myself for two years in determining the resistance of the various materials found at the site of that dam to the passage of water; that is, they were what I called filtration experiments.

Senator KITTREDGE. Which dam do you now refer to?

Mr. STEARNS. I am referring to the earth dam known as the north dike of the Wachusett reservoir, which is so similar to this Gatun dam.

Senator KITTREDGE. I wished to know whether it was this dam, the Gatun dam?

Mr. STEARNS. No. After having made all of those experiments, that north dike that I refer to was built. It is now completed, but the reservoir has not filled behind it so as to rise more than one-third of the height of the dam, so that it has not had the full test.

The CHAIRMAN. What would be the height of that dam?

Mr. STEARNS. The dam retains 65 feet of water, while the Gatun dam is to retain 85 feet.

Senator KITTREDGE. If it will not interrupt you, I would like to know the height of the water above the surface of the ground at the stone dam you have spoken of.

Mr. STEARNS. One hundred and twenty-nine feet. I think that is right. It is either 129 or 127 feet.

The CHAIRMAN. Proceed, Mr. Stearns, please.

Mr. STEARNS. In what I have said I think I have described my experience which has a special bearing upon work at the Panama Canal.

The CHAIRMAN. As I understand it, Mr. Stearns, you were appointed a member of the Commission. Was that your first connection with the Panama service, when you were made a member of the Consulting Board?

Mr. STEARNS. It was.

The CHAIRMAN. And you visited Panama last fall?

Mr. STEARNS. I did.

The CHAIRMAN. Had you ever been there before?

Mr. STEARNS. No.

The CHAIRMAN. If you will give us now a statement of your visit there in the fall, and then go on and make a statement in reference to this dam, we shall be glad to hear you.

Mr. STEARNS. I will say that before visiting Panama I had considered the subject of placing a dam at Gatun, and made drawings and presented the subject to the Board of Consulting Engineers on the basis of the borings that then existed. They seemed to be sufficient to show clearly that it was feasible to build a dam at that place. Then, as it was desirable to have more borings, I prepared a draft of a cablegram which was sent to the Isthmus, asking for additional borings directly at the site of the dam. At the time of the visit, which was at the end of September, we went to Colon, and for eight days we were examining the sites of the various works at the Isthmus.

Senator MORGAN. Is that all the time you ever spent on the Isthmus?

Mr. STEARNS. It is; and one day should be counted out from that, in part, which was Sunday, when we did not make a trip. Otherwise we put in good full days. I saw all parts of the canal. I presume it is not necessary to go into that at present.

Senator KITTREDGE. I wish you would, before you finish, Mr. Stearns, describe somewhat in detail the time that you spent on each feature of the canal.

The CHAIRMAN. I think he had better go on with the description of this first.

Senator KITTREDGE. Oh, yes; that is all right.

Mr. STEARNS. In connection with the Gatun dam, we examined the territory, found that they had a large number of men at work making borings. We talked the matter over with Mr. Maltby, the engineer in charge of that work, and saw the site of the proposed locks and of the proposed spillway and diversion channel, and also visited one part of the line of the dam where rock was exposed at the surface of the ground, and one where the French had started the diversion channel and then stopped digging on that line because they encountered the rock.

Senator KITTREDGE. That was at the west of the Chagres?

Mr. STEARNS. Yes; near the west end of this proposed dam.

Senator KITTREDGE. And west of the hill?

Mr. STEARNS. Yes; west of this central hill. It was on ground that was rising somewhat above the river and quite a long distance from the alluvial channels.

The point that I refer to is on this plan of the dam where the word "rock" is marked, near the westerly end of the dam [referring to plate 11]. Not all of the borings are shown on this plan, and, by the way, each of these black dots here represents the location of a boring. Not all of those on the line of the dam were made at the time we were there, but the information was sent afterwards.

In the engineers' office at Gatun they had the samples that had been washed up from the ground by those borings, and they showed, as far as I saw them—and I saw a great many of them—that is, very generally they showed, if not in all cases, that there was a large amount of clayey material with the material that was washed up. The borings that went down in the great depth, in the alluvial valley where the diversion channel is located, had not then been made. There, in the lower 58 feet, they found porous sand and gravel; but those had not been made at the time that we were there.

Senator KITTREDGE. That was at the extreme westerly end of the Gatun dam, was it?

Mr. STEARNS. No; not at the extreme end. It was at this point here [indicating on map]. You can see that it is quite a distance from the extreme westerly end.

Senator KITTREDGE. Is that west of the central hill?

Mr. STEARNS. Yes; this is the central hill that I have mentioned [indicating on map], and the alluvial valley between that and the hard land, rocky land, is represented by this comparatively short distance here [indicating]. This geological gorge, as it has been called in the testimony, is here [indicating on map] on this side of the central hill and again in the valley through which the canal itself passes.

Senator KITTREDGE. Will you please repeat your statement regarding the borings west of the central hill?

Mr. STEARNS. The borings west of the central hill had not been made at the time that we were at the Isthmus, and therefore I did not see the samples from those borings.

Senator KITTREDGE. What does the record since obtained show?

Mr. STEARNS. The record since obtained shows that that material was porous sand and gravel, in that lower 58 feet in this particular valley.

Senator KITTREDGE. To what depth did the borings go at that time?

Mr. STEARNS. Two hundred and fifty-eight feet is the deepest one.

Senator KITTREDGE. And substantially the same depth to the east of this central hill?

Mr. STEARNS. No, sir; to the east of the central hill I think the deepest boring was about 204 feet. That was the deepest that had been taken. Whether there was a deeper one found subsequently, I do not know.

Senator KITTREDGE. Will you not look at plate 12?

Senator TALIAFERRO. Do the borings all go down to rock?

Mr. STEARNS. Very nearly all. I think there was one that did not go down to rock, but I am not sure but what it was repeated afterwards and carried to rock.

Senator MORGAN. When you say rock do you mean real solid rock or indurated clay?

Mr. STEARNS. I mean indurated clay.

Senator MORGAN. You should call it by that name, because it is not rock.

Mr. STEARNS. It is rock, to all intents and purposes, as a foundation or for stability and standing. Now, I am referring to the indurated clay that is between Colon and Gatun; and at this point it is different from some of the other indurated clay in the Culebra Cut, which dissolves in water.

Senator MORGAN. This does not dissolve?

Mr. STEARNS. This does not dissolve, according to my information.

Senator KITTREDGE. But it washes out?

Mr. STEARNS. Not at all, I think.

Senator MORGAN. What do you mean, then, by that depression there on this blueprint—I will call it to your attention—

Mr. STEARNS. I would like to say just a word as to the reason I say it does not dissolve. Mr. Maltby told me that the French excavated a dry dock with vertical sides, and that I think must have been back in 1880 something—certainly it was the old canal company that did it—

and that that retained there its vertical sides without any trace of action by the weather upon it at all. That is not true of some of the indurated clay in the Culebra cut.

Senator MORGAN. This is the blueprint that we have been going on as being entirely correct, as to the proportions of the drawing, and also a correct statement of the actual borings that were made on the axis of this dam at Gatun. Here is a deep gulch [indicating on profile].

Mr. STEARNS. Yes.

Senator MORGAN. One hundred and how many feet below—

Mr. STEARNS. Two hundred and fifty-eight feet below mean tide.

Senator MORGAN. Yes. And here is another one [indicating on profile].

Mr. STEARNS. There is another one that is shown to be about 202 feet deep at its deepest point, below mean tide.

Senator MORGAN. And then it goes off at lower levels to the right and left on this map.

Mr. STEARNS. At higher levels.

Senator MORGAN. How did that gulch get in there if it was not washed out by water?

Mr. STEARNS. It undoubtedly was washed out, but I should like to explain and say how I understand that gulch to have been made.

Senator MORGAN. I wish you would.

Mr. STEARNS. That is, not only one of them, but both of them.

Senator KITTREDGE. Before he makes that explanation may I ask a question, Senator?

Senator MORGAN. Yes.

Senator KITTREDGE. Where is that deepest gulch with reference to the central hill?

Mr. STEARNS. It is west of the central hill and occupies the valley through which this French diversion channel runs. It extends between the points where my two fingers are touching the plan.

Senator KITTREDGE. And point out on the map where the other pocket, or whatever you call it, is, please.

Senator DRYDEN. The other gulch.

Mr. STEARNS. The other gulch extends about from the railroad to the central hill, between my two fingers, as I now have them on the plan.

Senator MORGAN. That is the one that is not quite so deep, but broader.

Mr. STEARNS. Not quite so deep, but wider, yes.

Senator KITTREDGE. How far is the railroad from the location of the locks as planned by the minority?

Mr. STEARNS. Well, it runs off at an angle, so that—

Senator KITTREDGE. About how far? I am not particular about the exact distance.

Mr. STEARNS. The greatest distance from the railroad to the locks is about 1,500 feet, and the shortest distance to the locks from right at Gatun is about 600 feet.

Senator KITTREDGE. Now, if you will answer Senator Morgan's question.

Mr. STEARNS. This is based on what I have heard stated by geologists, and what I have observed, in part.

Senator MORGAN. I wish, in making your statement, you would take into account this fact, also: The borings here show that upon this line [indicating on profile] water appeared; what is the elevation there?

Mr. STEARNS. That is about 50 feet below sea level.

Senator MORGAN. Water appeared there in the pipes that were driven down?

Mr. STEARNS. That 50 feet is not an exact statement; that is it approximately.

Senator MORGAN. And on the same level over here in the next gulch [indicating on profile] it appeared as you were driving your pipes down. Now, the conclusion that an engineer has stated here is that the water that appears here [indicating], and here [indicating] is connected by a conduit or an opening of some kind between the two, around this island. Is that your conviction?

Mr. STEARNS. Not at all.

Senator MORGAN. It is not? If you have a different explanation, I wish you would state it as you go along.

Mr. STEARNS. Let me explain, first, the formation of these gorges, as I understand it.

The CHAIRMAN. I think, gentlemen, if we will allow Mr. Stearns to go along and make his statement to the committee without interruption for a little while—

Senator MORGAN. I interrupted him to ask him to include that statement in his general statement.

The CHAIRMAN. I think we shall be better prepared to ask questions if we wait until he finishes his statement, because I think he is the authority on what he is talking about now in this country.

Mr. STEARNS. The earth, when it was formed, had no soil upon it. It was rock, and the rivers started to run down these rocky valleys, with perhaps very little depression. In the course of time they cut away a gorge, just as one sees out in the Denver and Rio Grande gorge, or in a great many other places. Water running over rock will cut a gorge down into the rock.

Senator MORGAN. You mean to say, I suppose, that the earth, when it was formed, was composed of rock and water?

Mr. STEARNS. Rock and water.

Senator MORGAN. Just those two elements?

Mr. STEARNS. Yes; I am going back a good ways. [Laughter.]

Senator MORGAN. Yes; a good ways.

Mr. STEARNS. There is nothing like starting at the beginning. The geologists speak of a comparatively new valley, that may be a million years old, perhaps, where the water has washed down and formed a gorge, but the sides have not run in enough to level themselves, and there is a steep gorge. That would be a comparatively new gorge, as they would call it, where the Denver and Rio Grande Railroad runs, and in a great many other places that you will readily call to mind, where there are deep gorges—the Grand Canyon of the Colorado is one of those.

Senator MORGAN. Then, if I understand you, and I want to get the predicate all right, the earth when it was formed was formed of rock and water, and there is no soil that was not formed by the operation of rock with water.

Mr. STEARNS. That is as I understand it.

Senator MORGAN. The soil was formed by the washing of water upon rock?

Mr. STEARNS. That is as I understand it.

Senator MORGAN. Very good.

Mr. STEARNS. In time water will cut a deep gorge down. It does not do that, however, below the level of the sea, because then there are no swift currents; and so, when you come to a gorge which is below the level of the sea, the geologists say that that land was originally at a higher elevation. Take, for instance, the Hudson River Valley: They say that the fact that the bottom of the rock gorge is 200 feet below the level of the sea, or more, at New York means that that land was once elevated so that the water was running swiftly enough to scour the material out of the bottom of that gorge and make a gorge.

In a similar way, here at Panama, this rock must have been at some time at a higher level than the ocean, and the Chagres River running down through there whittled out a gorge. The fact that it has done that does not mean that the rock is soft, because the Hudson River has gullied out a gorge in the same way in rock that is harder than this indurated clay. It is stated by geologists, and found to be a fact, that those gorges in rock always have a down-grade toward the sea. There were some attempts made here to see if they could not find a place where the rock would be high across these gorges, but I think it would be impossible.

On the Hudson I happen to know the soundings, and the depths from the sea level down to the rock up at Poughkeepsie is 144 feet, or thereabouts. At New Hamburg it has been mentioned in the testimony that it is 200 feet, and down nearer New York it is still deeper, showing that there was a down grade to that river at one time, when the land was elevated above the sea.

Senator MORGAN. I have always understood that the glaciers had something to do with forming these river channels.

Mr. STEARNS. I do not think that is generally admitted by geologists. They may have had something to do with it, in cases, but I have heard it stated otherwise by eminent authority.

Here at the Chagres the rock gorge has a down grade to the sea. I should have said, first, that this land, after this gorge was formed by the action of the water, sunk below the level of the sea by a gradual subsidence of the land, such as is known to have taken place in many parts of the world, and the rock gorge is shown now to be with a continual down grade to the sea, so far as the tests have been made; that is, at Gamboa, the bottom of the gorge, which is not a deep one at that place, is at sea level. The rock is about 50 feet below the ground there, and the deepest place in the rock is at sea level. Coming down the river to the next place where borings have been made, I think it may be near Buena Vista, although I am not sure of this, that depth to the rock is somewhere in the neighborhood of 140 or 150 feet. At Bohio, still farther down, the greatest depth to the rock is 168 feet; and getting down to Gatun, the greatest depth to the rock is 258 feet.

Senator KITTREDGE. You mean indurated clay?

Senator HOPKINS. He has stated what he understands by that. He calls it rock, in his testimony.

Mr. STEARNS. In general it is rock. I think it was formed as rock, although I am not an expert on that side of the question.

Therefore I believe that that gorge was formed there by the action of water, and after it subsided and the currents became quieter, then it was gradually filled up with earth brought down by the river.

Senator MORGAN. I want to call your attention to a divergence of opinion between you and other gentlemen who do not profess to be geologists, but who are engineers of high rank. They produced samples of this stuff here, called indurated clay, and they seemed to be of the opinion that it was formed by volcanic action, probably, and was silt; at all events, deposited as silt in the bottom, beneath the waters of the Chagres River and the waters of the surrounding country.

Mr. STEARNS. I should not think that was the case; although I do not know as to its formation.

Senator MORGAN. You think it was an original formation of rock?

Mr. STEARNS. I think it has been scoured out.

Senator MORGAN. You think it was an original formation of rock? They claim it was formed by the silt settling in the water, and you claim that it was an original formation of rock?

Mr. STEARNS. I do not believe there is any indication that that is the case. These gorges look as if they had been scoured out of the rock, and I believe they were—not like something that is made by settling in that way. They are unusual shapes that you see there, and the shape itself suggests the scouring action of water.

Senator MORGAN. As if it had been there and been washed out?

Mr. STEARNS. Yes.

Senator MORGAN. That is what I think; and I think it will be washed out again, if you ever get head enough of water on it.

Senator DRYDEN. This is not material, but do you suppose that these gorges were made here because this rock was of softer quality than the rock adjoining?

Mr. STEARNS. Very likely. Water will scour in the lines where there is the least resistance, and if any particular rock is softer than other rock that will be scoured faster. I know an instance of that kind where granite was adjacent to a schist or shale, and the schist or shale had scoured away so that it left that granite as a vertical wall—an overhanging wall, in fact, some 40 feet higher than the shale; that is, the shale had scoured down so much more readily. That was the case at the site where the masonry dam I have spoken of was built.

Senator DRYDEN. And would you suppose that that softer quality still persists up to the present time?

Mr. STEARNS. It is not a hard rock at all.

Senator DRYDEN. No; but I mean softer than the adjoining rock?

Mr. STEARNS. I do not believe there is very much difference. If a gorge got started in some place where it was soft the concentration of current in the middle of the gorge would continue to cut on that line even if it were harder than some of the adjacent rock.

Senator DRYDEN. That seems reasonable.

Mr. STEARNS. I was speaking of the fact that this alluvial material which fills the gorge was to a large extent brought in after subsidence of the land, so that the currents were checked by being below sea level. That is, after it dropped, there was no fall to produce scouring action, and the gravel is brought down from the Chagres, we will say, above Gamboa. If this gorge had always remained above sea level, it might have been that there would have been no deposits in it, or, if any deposits had been made, they would have been of coarse material.

But after it subsided, there was, of course, less current, and the gravels brought down by the Chagres River above Gamboa would settle as soon as the currents were retarded slightly and the finer materials would go on farther down.

The evidence of borings, both at the Gatun dam and within a mile or two of it upstream, is all to the effect that that material was deposited in sluggish currents. Mr. Wallace, in a statement before us, suggested that—and I think it is generally recognized—that the material in the lower part of this estuary was formed when the gorge sank below the level of the sea, and was then filled with fine material. There is coarse gravel up at Gamboa, and just below Gamboa there is one place there where there are stones, I should say, as big as my two fists.

Coming farther down the stream where the Chagres is crossed by the railroad one can see gravel bars; and farther down they are not as plain. Going still farther down, they disappear. That is the result of superficial observation, and it is also the result of the borings throughout. I have not them all here to show to you, but take, first, the proof that that material down there has been deposited in sluggish currents, and I can call your attention to a good many borings.

I see I had omitted one thing, the material deposited in that deepest gorge was not deposited in a sluggish current, apparently; that is, the lower 58 feet of it was deposited under conditions in which coarse material was brought along, and the fine material was washed farther out to sea. So that there is, down in that lower part there, sand and gravel which is not as full of fine material. I should not have said that the fine material was all washed out to sea, because in all these deposits of gravel there is sand deposited with stone and finer material, very often. Just referring to that point once more, I know in one place where clay is shown within that 58 feet—clay alone.

Senator MORGAN. You are now referring to the deepest of the borings?

Mr. STEARNS. Yes; the lower 58 feet.

Senator MORGAN. Yes.

Mr. STEARNS. But otherwise, in that lower 58 feet—it may be a little higher than 58 feet in places—the clay is a very large component of the material which was deposited there. When I made the first statement to the Board of Consulting Engineers on this subject—

Senator MORGAN. Let me ask you, underlying that clay is there any wood?

Mr. STEARNS. The wood has been found more or less throughout all these borings.

Senator MORGAN. Underlying the clay that you speak of is there wood?

Mr. STEARNS. Not that particular clay that I mentioned last.

Senator MORGAN. Well, any clay?

Mr. STEARNS. Oh, yes. In this deposition of material in a sluggish current there is wood and vegetable matter at times, and shells.

Senator MORGAN. In other words, then, this has washed out there and been filled up by the waters of the Chagres River, bringing down wood and clay and sand and finer material, and also, sometimes, boulders?

Mr. STEARNS. Not boulders.

Senator MORGAN. As far down as Bohio they find boulders?

Mr. STEARNS. Oh, yes; but not down here.

In connection with that, when we first met we had given us certain printed information, and it included a report by Mr. Nichols, who had charge of the borings in the vicinity of Gatun.

Senator KITTREDGE. Was Mr. Nichols afterwards succeeded by Mr. Maltby?

Mr. STEARNS. Yes; Mr. Nichols is still down there, but on other work.

Senator KITTREDGE. Do you remember when Mr. Maltby succeeded Mr. Nichols at this point?

Mr. STEARNS. No; Mr. Nichols went down on the steamer with us, after a leave of absence, the last of September, and I think that when he went back there he was placed on work up at the Culebra Cut. Probably that was the time of the change, although it may have been earlier.

Mr. Nichols said, as a part of his report to the Isthmian Canal Commission: "In the test holes no bowlders have been encountered." These are the test holes in the vicinity of Gatun. He also says: "In the valley the material above the rock is composed of clay—clay mixed with sand in proportions varying from almost pure clay to nearly pure sand, and some streaks of shells and vegetation in sundry stages of decomposition, which indicated a fine material deposited in sluggish currents."

My own analysis of the material, made before these later borings were made, was this: I found that there were fourteen available borings that were made with reference to dam location in the valley east of the island at Gatun; that is, upstream from the island shown on this plan.

Senator KITTREDGE. Do you mean that central hill?

Mr. STEARNS. There is another hill that is about a mile long, perhaps a quarter or a half a mile upstream from this central island that is on the map of the dam.

Senator KITTREDGE. That is in a southerly direction, then, from the central hill that you have mentioned?

Mr. STEARNS. Yes. The lower part of this hill that I am speaking of now is shown on this plat.

There were 14 borings in the valley east of this island, and I analyzed them to see how much sand or gravel was encountered. Two of them did not have sufficient information. In the other 12 there was neither sand nor gravel encountered without clay was mixed with it; that is, it was often marked "sand and clay," but no sand alone was noted.

Senator KITTREDGE. Will it interrupt you if I ask some questions?

Mr. STEARNS. No, sir.

Senator KITTREDGE. Where were those borings made with reference to the proposed Gatun dam site?

Mr. STEARNS. There. [Indicating on map.]

Senator KITTREDGE. East of this island that you have mentioned?

Mr. STEARNS. East of this upper island.

Senator KITTREDGE. And about a mile south of the proposed Gatun dam site? Is that right?

Mr. STEARNS. No, sir; some of them were under the proposed Gatun dam site, and some of them were upstream from it. Two were under the dam site, and then there are some of them shown on this plan marked 205, 206, 207, 209, 211, 212.

Senator KITTREDGE. They were, then, except two, south of the proposed dam at Gatun?

Mr. STEARNS. Yes; ranging from perhaps 1,000 feet.

Senator HOPKINS. South would be upstream?

Mr. STEARNS. Yes. Ranging from perhaps a thousand feet, say, to a mile or a mile and a half. On the other side of this island which I have mentioned there were thirteen borings, of which I think only one is under the site of the dam as now proposed, and the others were within that distance of a mile or a mile and a half.

Senator KITTREDGE. How deep were those borings?

Mr. STEARNS. Those west of the island ranged from 116 feet to 204 feet.

Senator KITTREDGE. And how deep were they east of this island?

Mr. STEARNS. The smallest depth is 64 feet; evidently not in the bottom of the gorge; and the greatest depth was 201 feet.

Senator KITTREDGE. Did those borings disclose the presence of water at any point below the surface?

Mr. STEARNS. There was no note made to that effect, so far as I recall.

Senator KITTREDGE. You are speaking now of the borings made by Mr. Nichols?

Mr. STEARNS. These are borings made under Mr. Nichols's direction, as I understand. In fact, he told me that he made them.

Senator KITTREDGE. And his report does not disclose water, as I understand it?

Mr. STEARNS. No mention is made of it.

The thirteen borings west of the island showed sand without admixture of clay for 10 feet in one boring that was 187 feet deep; for 1 foot in a boring that was 146 feet deep; for 8 feet in a boring that was 205 feet deep, and for 5 feet in a boring that was 193 feet deep. In none of the others was there sand without clay noted. For records of gravel, gravel was noted in two cases for a depth of 1 foot in each case.

Senator KITTREDGE. At what depth?

Mr. STEARNS. I have not the record of the depth, but the total depth of one of these borings was 204 feet and the other was 197 feet.

The way I interpreted those borings was that there was so little clear sand or gravel that it was a very strong proof that that material had been deposited in sluggish currents and that it would be impervious, and I think that view was verified by the borings which were afterwards made on the line of the dam, except in that lower 58 feet which I have referred to on several occasions.

Senator MORGAN. You are not now speaking of the clay, but of what was superimposed upon it?

Mr. STEARNS. This is the alluvial material which filled gorges in the indurated clay.

Senator KITTREDGE. Where, with reference to the proposed site of the Gatun dam, was the boring that disclosed 10 feet of sand?

Mr. STEARNS. It is boring No. 54. It is not shown on this plan. I see Nos. 55 and 56 there, so that probably it was in that neighborhood. I am not sure.

Senator KITTREDGE. Then it was south, or upstream?

Mr. STEARNS. From the dam; yes.

Senator KITTREDGE. About how far?

Mr. STEARNS. The two that I have noted are about 1,500 feet upstream from the dam—a quarter of a mile.

Senator KITTREDGE. How close were those borings to each other, both east and west of the island, upstream from the proposed dam site? I do not care for any accurate figures.

Mr. STEARNS. They varied. Sometimes they were scattered and sometimes they were near together. Here are five in a bunch, and the greatest distance from the extreme ones is 800 feet.

Senator KITTREDGE. Do you find any of the borings that you are now describing nearer together than 800 feet?

Mr. STEARNS. Oh, yes. Here are two. The nearest two on this plan are a little over 200 feet apart.

Senator KITTREDGE. Do you find any borings, either east or west of the island, upstream from the proposed Gatun dam site nearer than 200 feet?

Mr. STEARNS. The nearest are just about 200 feet, possibly 175. This plan is rather small.

Mention has been made of the fact that wood is encountered, and also that vegetable matter is encountered in some places. I rather welcome the appearance of vegetable matter, because it was evidence, as it seemed to me, of the fineness of the material that was deposited there. Moreover, vegetable matter mixed in with sand makes it impervious to water.

I have done a great deal of work on that line, so that I know. Chunks of wood would not, but I do not see that they have any special significance. They would be thoroughly surrounded by sand; they are impervious in themselves, and wood under water lasts practically forever. If one were building a masonry dam on top of this alluvial material, then it would be a very serious matter to have organic matter in it, because it would settle; but in building a dam such as is proposed, with a great mass of earth, the weight on it is such that if that material settles, and it will if there is some vegetable matter there settle a little, the tendency would be rather to crowd that vegetable organic matter in with the grains of sand, in between the grains of sand, and make it all the more tight.

If it compresses it means that it puts the particles closer together, whether it is organic material alone or whether it is organic material mixed with sand. But in a dam as proposed here, with a height at the highest point of 135 feet, there is a pressure of about between 6 and 7 tons to the square foot on this earth, and the settling could not make any cracks that would go longitudinally in that material. Under such an enormous pressure it is bound to squeeze together and follow down. I do not know as I am making that clear.

In some of this material, not at Gatun, but on my own work, that had organic matter in it I put some jackscrews on it and brought a pressure of 20 tons on a small area—not as much per square foot as this would be—and when I compressed that material having the organic matter in it it made it so solid that, while it was soft surface soil at first, before pressure, after it had been pressed with that weight it was so compact that one could hardly drive a pick into it. With this enormous weight, if there is any compressible material, it will tend to crowd it together and make it solid.

Senator DRYDEN. You spoke of the sinking in this dam. Whatever it might be it would occur during the process of construction and by the time of completion?

Mr. STEARNS. Certainly.

Senator DRYDEN. Would there be any danger of its going on after the dam was completed?

Mr. STEARNS. I think it might continue somewhat after. I once built a bank that was 30 feet high on a great depth of mud. The mud was composed of organic matter and clay that had been washed from neighboring hills and drifted into this position; and that settled for three or four years, and went down a total of about 3 feet. But that was a great depth of mud; here it is sand and clay, which would not settle, except for some limited portions where some vegetable matter is encountered.

Of course I can not say accurately; but I should say that it would not probably be, under that pressure, more than 2 feet in all. I should expect that 1½ feet of the settlement would occur, if it occurred at all, during construction, and that it might go 3 inches more afterwards. That is merely a guess of what might happen. I should not think there would be more than that in this place. If there was more organic matter it might be twice or three times that, but about in that proportion. That is, most of it would occur when the weight was put on it.

Senator DRYDEN. I do not want to interrupt the course of your statement. I do not know whether you have now arrived at a point where you want to express an opinion as to the durability and sufficiency of a dam constructed in that way.

Mr. STEARNS. Well, I am perfectly willing to express an opinion—

Senator DRYDEN. If you have not arrived at such a point I will wait.

Mr. STEARNS. I have still more to say, if you gentlemen wish to listen, as to the ground for that opinion.

Senator DRYDEN. Yes.

Mr. STEARNS. I have not much faith in an opinion that is merely an engineering guess, without some grounds for it.

Senator DRYDEN. I would prefer, then, to have you go ahead.

Mr. STEARNS. In some of the testimony which has appeared before the committee it has been stated that this whole matter here was an engineering guess. In fact, when the matter came up before the Board of Consulting Engineers, I think it was at least six weeks after I made my first statement to the Board before any criticisms that I recall were made unfavorable to the safety of the dam, and then it was made by only one member of the board, who did not criticise it at all in detail, but said it was an engineering guess, to which he would not subscribe his name.

I wish to say very distinctly that this is not, in my opinion, an engineering guess. It is as capable of demonstration as any problem that comes up in engineering; and further than that, that there has been allowed a factor of safety that is beyond all factors that have been allowed in the past.

Senator MORGAN. Beyond all precedent?

Mr. STEARNS. Beyond all precedent, except in the case of this dam which I built, which is the precedent for this particular construction.

I am going to attempt to make this clear to laymen, and I think I can. The forces which act to move a dam of this sort from its position, to wash it away, or push it away, are, first, the pressure of the

water against this mass, trying to slide it downstream. Possibly this may not be entirely clear as to what this plan is. [Indicating plan of Gatun dam.] This, by the way, is the Gatun Lake, the blue representing the water, at elevation 85. The yellow color here is the dam, with its proper proportions drawn upon the scale upon which engineering works are generally drawn, and not on the minute scale in which it is shown in the report.

Here is a suggestion of 200 feet of stone at the lower end. The rock is shown here, 200 feet below the level of the ground, the level of the ground being shown by this line, and this is the alluvial material which has filled the gorge in the rock or indurated clay.

Senator KITTREDGE. What is the upper line, just below the line indicating the bottom of the water—are those dots along there?

Mr. STEARNS. That is some of the draughtsman's artistic work, showing the dots here and here [indicating] merely to emphasize it, or give it a proper border, or something like that. It is of no significance whatever.

Senator KITTREDGE. That is what I thought.

Mr. STEARNS. Just the same as these little marks here in the rock are not intended to indicate that there are seams there, but just to make it look pretty.

The way in which dams have failed on some occasions—for instance, the Austin dam—is by sliding; that is, the water pressure against the dam was sufficient to cause a section of the dam to slide downstream. I do not think it needs the assistance of figures to show that that dam will not do so. That weighs about, as I recall it, sixty-three times as much as the pressure of the water against the upstream space. That, I think, should be obvious to a layman or anybody else—that that dam could not be pushed away as a whole.

Senator MORGAN. That would mean that the pressure perpendicularly is sixteen times as great as the lateral pressure of the water?

Mr. STEARNS. Sixty-three times.

Senator MORGAN. Sixty-three times as great?

Mr. STEARNS. Your force of gravity is sixty-three times the force that gravity produces horizontally from the water.

Senator MORGAN. There has been a point made there by one engineer or two that I just wanted to mention, and that was that this substratum of indurated clay was liable to compression on account of the great weight upon it.

Mr. STEARNS. I wish I had a sample of that indurated clay here.

Senator DRYDEN. We have had one.

Mr. STEARNS. I wonder if it was from this section.

Senator DRYDEN. I think it was.

Senator HOPKINS. Mr. Bates brought it here. I do not know where he got it.

The CHAIRMAN. He took it away with him.

Senator KITTREDGE. He got it down in the Gatun lock or in the hills. It was not at the dam site.

Mr. STEARNS. I had a core of that at one time. In fact, I saw many of them, but as one handles it and looks at it they would call it rock; and that is what it is, a fine-grained rock. I found by taking my knife that I could cut it. It looks something like a fine-grained whetstone, only it is softer than the whetstone that you use.

Senator DRYDEN. How would that compare in hardness with Indiana limestone, which is used for building purposes?

Mr. STEARNS. Oh, I do not think it is as hard.

Senator DRYDEN. That is very soft when it is taken from the quarry.

Mr. STEARNS. I am not familiar with it.

Senator DRYDEN. And it becomes harder with exposure to the elements.

Senator MORGAN. That is, from exposure to air and heat of the sun, but not to water?

Senator DRYDEN. I suppose not.

Mr. STEARNS. It would be very nearly like some soapstone I have seen, rather softer, I think. You can cut soapstone with a knife.

Senator KNOX. I tried it the other day with a knife, because it looked exactly like soapstone. I got that impression when I picked it up.

Mr. STEARNS. For any such pressures as come here that is just as good as the hardest rock that you ever saw, and it gave the impression of being very compact, so it would let no water through. I should not think there would be seams in it from the appearance of the rock. It could not let water through if there were seams.

The dam, I suppose it has been stated to you, is half a mile—2,625 feet—through. If a dam can not fall by the pressure of water pushing it away, as a whole, it must fall, if at all, through the water going through underneath or through the dam, and it could not come out here [indicating on map] after coming through, because this as high as the water in the lake itself. Down here [indicating]—

Senator KNOX. Will you permit me to suggest that when you say "here," and indicate on the map, it will not appear clearly in the record as to what point you are indicating? I suggest that you specify distances and figures, so that the record will show what you are referring to.

Mr. STEARNS. Yes; I can modify that, then.

Senator KNOX. Say the outside of the dam, or whatever it is.

Mr. STEARNS. Three hundred and seventy-four feet from the water line the dam is as high as the water in the lake and absolutely no water can come out at that point. And at a point halfway of the thickness of the dam, the distance below the water surface is approximately about 25 feet, so that water could not come through this material and come up here. It would come up, if at all, away down toward the lower end of the dam, as springs.

Senator MORGAN. It would come up at the point of least resistance?

Mr. STEARNS. Yes, sir.

Senator MORGAN. Wherever that might be found?

Mr. STEARNS. Yes; and that would be toward the lower end of the dam.

Senator MORGAN. Probably.

Mr. STEARNS. Yes; probably.

Senator MORGAN. Yes.

Mr. STEARNS. With very little doubt. Now, if this is absolutely impervious, there would be no water to come out; but I will—

Senator MORGAN. Let me ask you, if you please, in these borings did you discover any coral?

Mr. STEARNS. None at all.

Senator MORGAN. None of them?

Mr. STEARNS. Not at this dam site.

Senator MORGAN. Did you at any other dam site that you bored across that valley?

Mr. STEARNS. I did not see any boring that showed coral. I do not think there was any. That is all found, I think, down toward Colon and Cristobal.

First, I will take up the point that this is tight underneath here, and there would be no water. That, I believe, is very well shown by the borings, and by one other thing that I did not mention. I had particularly requested, in my communication to the Isthmus—sent through the proper parties, of course—that they take a sample of the material pumped up from the boring hole in a pail, without letting anything spill over from the pail, so that it would contain both the fine material and the coarse material.

Those samples are taken by letting the water run into a pail, and then letting it overflow, in which case the coarse material is obtained and the fine material is not preserved. This sample was taken as I requested, and what we saw in the bottom of the pail was sand and fine material mixed with it, so that one would say it was practically impervious; and then the last thing that settled in the pail was the fine clay, which left a shiny surface over the whole thing, about as you see in the bottom of a mud puddle in the street after a rain, and that makes the bottom of the mud puddle pretty nearly water-tight. But it showed very clearly, as a single sample, that there was this fine clay in the material washed up in sufficient quantities to make it substantially, if not absolutely, water-tight.

Senator ANKENY. Is that surface mica? What is that shiny surface?

Mr. STEARNS. This was all clay—finely divided clay—that settled in this pail of water.

Senator ANKENY. Is it a mica?

Mr. STEARNS. No; it is a clay; alumina or some compound of alumina.

Senator KITTREDGE. From what depth below the surface did this appear?

Mr. STEARNS. I do not remember that particular sample.

Senator KITTREDGE. Do you remember from what boring?

Mr. STEARNS. I do not. It was one made so that they should give us a characteristic sample, and by this separation which occurred from the material settling in the pail it showed this very finely divided clay.

Senator KITTREDGE. Do you know about where the boring was made?

Mr. STEARNS. It was made on the line of the dam.

Senator KITTREDGE. About where?

Mr. STEARNS. Do you remember, General?

General DAVIS. I can not recall. I remember the incident.

Mr. STEARNS. I think it was in the valley, nearest Gatun, on the east side of the central island.

General DAVIS. That is quite correct. I recall it now. That is where they began that work. We were there just as they began it.

Senator KITTREDGE. How near to the railway station at Gatun?

Mr. STEARNS. That would be nothing but a guess. Within a thousand feet of it.

Senator KITTREDGE. That is quite a distance.

Mr. STEARNS. That is as nearly as I can get at it. One way of determining the safety of a dam of this sort with respect to filtration through the material underlying it is by making assumptions that instead of being impervious, that material is a pervious material; and then it becomes capable of estimation as to how much water will pass through these alluvial sections.

Suppose that, instead of the impervious material here, there was a fine-grained medium sand—I have taken that as being a medium-sized sand—I have made experiments, and they have been made by Mr. Hazen also, as to how much water will pass through such a sand, and the computations showed that if there were this medium sand, the total quantity which would pass through would be 10 cubic feet a second.

Senator KITTREDGE. Please state very briefly the conditions under which that test was made.

Mr. STEARNS. I shall be pleased to do that. I thought I would state the results first.

Senator KITTREDGE. That is all right.

Mr. STEARNS. The testimony that has already been given here as regards this matter seems to me to be very incorrect.

Senator MORGAN. Whose testimony?

Mr. STEARNS. Professor Burr's. This is on page 1616. He says: "It has been stated and is stated in the minority report that the computed seepage under the Gatun dam can never exceed about 10 cubic feet per second, and it is said that this is too small a matter to be the cause of any apprehension."

Now, the minority report does not make that statement at all. The minority report says on page 70:

"If, however, a condition which does not exist be assumed, and all of the alluvial material beneath the embankment of the dam were considered to be a clean and reasonably uniform sand of medium size, the total amount of filtration would then be for the whole length of the dam only about 10 cubic feet per second."

The minority says that that filtration is insignificant, and that if you assume a condition by which that is medium sand then it would only be 10 feet a second.

Senator MORGAN. What sand is spoken of there? Is any material of that description found in the indurated clay or in these gulches that have been mentioned?

Mr. STEARNS. The indurated clay is, in my opinion, absolutely water-tight.

Senator MORGAN. That sand spoken of is not in the indurated clay?

Mr. STEARNS. No; this is the alluvial material—

Senator MORGAN. In the deposits upon it?

Mr. STEARNS. That is it.

Now, if a fine sand be assumed, the tests that I have made show that the quantity would be $2\frac{1}{2}$ cubic feet per second, and if a very fine sand, only two-tenths of a cubic foot per second. That is, taking assumptions which, with the possible exception of the last one, are more favorable to filtration than this actual material that is here, then the filtration would not be an amount that would cause any upheaval at this end to interfere with the safety of the dam.

As to what experiments or tests warrant these statements, I will tell you.

Most of the experiments which have been referred to as laboratory experiments were made with a galvanized-iron tank filled with the said or other material to be tested, the water being applied at the top, at a constant level, and drawn out at the bottom through a faucet, and with gravel underdrainage.

Senator KITTREDGE. You are now speaking of the conditions under which the tests were made which I asked for a few minutes ago?

Mr. STEARNS. Yes. The pipes extended through these tanks, through the material which was being tested, at two levels, 3 feet apart. The faucet would be closed to a considerable extent, so as to cause the water to back up in these pipes, and the pipes being at the side of the tank with a glass tube, so as to show the height to which the water would rise, one of them would show the pressure of the water at the upper point, 3 feet above the lower one, and the other would show the pressure of the water at the lower point; and the difference in level between the water in the two tubes would represent the amount of resistance that 3 feet of sand would offer to the passage of the quantity of water then passing; and the water passing was measured carefully. By opening or closing the faucet different quantities of water could be made to pass, and the differences in amounts of resistance caused in passing through 3 feet was measured. It is rather a hard matter to explain.

Senator KITTREDGE. When was that test made?

Mr. STEARNS. These tests that are referred to in this pamphlet were made in 1891.

Senator KITTREDGE. Where?

Mr. STEARNS. They were published in 1891. They were made at the Lawrence experiment station of the Massachusetts State board of health, of which I was chief engineer.

Then another series of experiments were made in the same general manner under my charge, which covered a period of two years, in 1895 and 1896, I think. It may have been a year later. They were made with apparatus of this same kind and with surface soil taken from the ground, with gravel, both fine and coarse, and with sands of four different grades, the finest being very fine.

Senator KITTREDGE. Where were those tests made?

Mr. STEARNS. They were made in Clinton, Mass., on the Metropolitan waterworks, of which I was chief engineer. The tests made there confirmed those made at Lawrence. There was a question whether such tests would be applicable to the horizontal filtration, because they are made with the water going down vertically. So I had another set of tests made in a tank, a long wooden box 60 feet long and 6 feet wide and 8 feet high. That was filled with the material to be tested, and the water at one end was supplied as it would be at a dam. The water was raised 8 feet above the bottom of the box, the other end of the box being kept empty. As a result we found that the horizontal filtration of water through the materials, or a particular material tested, was the same as the vertical filtration, showing that it applied to both.

Senator KITTREDGE. Where were those experiments made, you say?

Mr. STEARNS. They were made at Clinton, Mass.

The next test was made to ascertain whether materials under a great pressure would behave differently from those under a pressure of only a few feet; and the material to be tested was put in an iron pipe, about

10 inches in diameter, and I think about 10 feet long, and a flange was bolted on the upper and lower ends, and the pressure due to the water supply of the town of Clinton was applied to it—something like 150 feet head. And the same laws applied under 150 feet head acting upon 10 feet of material as applied to these lower pressures.

You see I am trying to show that this is not an engineering guess; but that the engineering guess comes in in not applying this information. The laws which are deduced are simple, and I think can be understood. The quantity of water that will filter through sand or other material varies with the pressure. That is, the quantity that would filter underneath the Gatun Dam, if it had in this alluvial valley a porous material, is proportionate to the pressure; that is, with half as much pressure acting to force water through, there would be half as much go through, and so on. The experiments showed that it was directly proportioned to the pressure.

Now, as to the resistances; that was also found to be directly proportional to the length of filtering material upon which tests were made. That is, if the distance through this dam were only one-half as great as this total distance, then there would be only half as much resistance offered to the passage of water. I think a person would naturally agree that that would be the case, and that is what is found by tests. That is, if it filters one-half the distance, it will filter with the same head of water twice as fast.

Putting those things together in what an engineer would call a formula means that the quantity of water which will filter beneath any dam or through any other material is proportional to the water pressure divided by the length through which it filters. That is, the amount that would filter in a case like this, in comparing with another dam, is 85 feet divided by this total length, or, leaving out a little at each end, it would mean that it was a pressure of 4 to every 100 feet of resistance. That is because the relation of this depth to the resisting length is four to a hundred, approximately.

It is rather less than that, but it is convenient to call it four to a hundred. And the fact of this 85 feet head here is not important without one also takes into account the distance through. That is the one thing that needs to be considered for filtration, the filtration of four pressure against one hundred of resistance, and it would be the same, substantially, as a dam 100 feet thick and with 4 feet of water against it, or 200 feet thick with 8 feet of water against it. I do not know whether I have made myself clear, but the result of that experiment and of using common sense is that the quantity of water which will filter through any dam can be diminished almost at will by increasing the thickness of the dam.

To sum up what I am saying, that even if that were a porous sand of medium size there would not enough water come through here to disturb the dam; and the material is shown conclusively by the borings to have so much fine material in it that it would not filter one five-hundredth part of what medium sand would filter.

I have not attempted to go into the other laws deduced by experiments, but I will say a word or two. It is the finer particles in a sand or gravel that govern the amount of filtration, and not the average size of the whole mass. If there are 10 per cent of fine particles, it has been found that that governs the filtration.

In the experiments which I made myself—

Senator KITTREDGE. You now refer to the experiments which you have already mentioned?

Mr. STEARNS. Yes; at Clinton. These were the results: A soil, or surface loam taken from gravelly and sandy territory, and used for an experiment, would let through a quantity which I will call unity—1. Very fine sand, of which I had a sample and failed to bring it here, would let through 14; a fine sand, 176—that is, 176 times as much as soil, which is taken as the unit—the medium sand, which I have been using for the purpose of this illustration, let through 784 times as much as the surface soil; and the coarse sand, which was of uniform grade, let through 4,353 times as much as the surface soil.

Now, this material is, with its fine clay, comparable with that surface soil alone, which had the fine particles or what the geologists would call rock flour in it, and also some organic matter which is in the top soil. That is, the quantity that filters varies as the square of the diameters of the finer particles, and that is the way it works out in practice.

The CHAIRMAN. You are getting beyond our depth, now, Mr. Stearns. [Laughter.]

Mr. STEARNS. I am going to say just one other thing that you can appreciate.

I built an experimental dike in this large wooden tank that I spoke of.

Senator KITTREDGE. The Clinton experiment?

Mr. STEARNS. At Clinton, yes; and raised the water 8 feet against that dike made of this material taken from the surface of the ground. That is the section of the experiment [exhibiting section shown in pamphlet]. The water that passed through that dike was so small in quantity that it would not run in a stream from the end. As I remember, it was dripping into a bottle, when I saw it, at the rate—well, I think it was 30 drops a minute; I will not stop to look it up; but it was what a man would call water-tight. Perhaps the experimenter would say it was filtering at the rate of about a bottle full in half a day, I think.

Senator MORGAN. If you have come to a point in your statement where you wish to take up a new subject, I want to ask you, before you proceed to it, a question or two about that map.

Mr. STEARNS. I have still something more to say—

Senator MORGAN. Go ahead, then.

Mr. STEARNS. I will try not to be as technical as I have been.

It has been stated in the testimony of Professor Burr, on page 1540, that dams had failed, and he said that there were numerous instances. He was asked to give one or two instances, and he mentioned the failure of the Mill River reservoir dam at Williamsburg, Mass. This dam, built in 1865, failed in 1874, at a time when the water was 4 feet below the top, and it failed by the sloughing or caving of the lower end of the dam. A committee of the American Society of Civil Engineers was appointed and investigated the failure. They found that there was a specification which was not signed, and they could not find that there was any engineer responsible for the design or construction of the dam.

The dam was an earth embankment with a core wall 16 feet wide on top, with side slopes of $1\frac{1}{2}$ horizontal to 1 vertical. This is 25 horizontal to 1 vertical. The masonry core wall was 2 feet in thickness at the top and 5 feet 9 inches in thickness at the bottom. It was built in dry

stone and grouted, a way that engineers would not build it now. At the site of the dam there was said to be by this committee a washed porous gravel, and below that hardpan. The specifications required that the core wall should go 3 feet into the ground, so that it would not settle, but said nothing about carrying it down to the hardpan, which was only a few feet lower, so that it would cut off the water.

They did not seem to appreciate the purpose of a core wall; and they found that it was not carried down to the hardpan, but rested on this porous gravel. The slopes of the dam were found to be altogether too steep for safety. They were only $1\frac{1}{2}$ horizontal to 1 vertical; and that is about the slope that gravel when dumped naturally takes itself. It is somewhere between 1 and $1\frac{1}{2}$ to 1; so that it had not much more than the stability required to prevent it from sliding off on the downstream side itself; and the water pressure and the water leaking through this dam, together with the tendency of the earth to take a flatter slope, caused it to slough and go away. I have a section here which I will show you.

Senator MORGAN. What was the depth of the water?

Mr. STEARNS. Thirty-nine feet. It was 4 feet below the top of the dam and had been somewhat higher. It seems to me if there is any lesson taught by that dam it is that an entirely inadequate dam, built without engineering supervision and without engineering designs, stood for nine years before it failed. I have here a section of the dam.

Senator KITTREDGE. This dam of which you are speaking?

Mr. STEARNS. Yes. I had this prepared this morning. (Mr. Stearns thereupon proceeded to compare the section just referred to with the section of the Gatun dam which was exhibited before the committee.)

The comparison between the two dams, if this had been made so as to show 39 feet depth of water, would not have been easily made, and therefore I have enlarged this section proportionately. It has the true proportions, but it has been enlarged in the proportion of 85 to 39 to show what it would be if built to these same proportions, but with the water against it that is to be against the Gatun dam. That is the relative size of this dam, which is brought here as an instance, out of many, as to a dam that has failed, which might serve as a precedent for the failure of this dam.

Senator MORGAN. Is that a rock core where your finger rests?

Mr. STEARNS. Yes, sir; that was built of rubble and grouted as they call it. That is, they built up rubble-stone dry first, without any mortar, and then they poured in this mortar. Sometimes it fills the openings, and sometimes it does not. When it is not built under inspection—

Senator MORGAN. That was the only core in the dam?

Mr. STEARNS. Yes; and that did not go down to the impervious material, so that the water had a pretty free opportunity to come through here, and this gradient from here down to here [indicating on section], instead of being 4 in 100, would be, I should say, 40 to 100.

Senator MORGAN. At what point did the break commence?

Mr. STEARNS. This slid off [indicating]. I think the water came through and saturated this material, and it would not stand at that very steep angle.

Senator KITTREDGE. Came through where?

Mr. STEARNS. Underneath this wall, and probably through it also.

Senator KITTREDGE. You mean below the foundation?

Mr. STEARNS. Partly below the foundation, as this was built with porous gravel, the whole dam, according to the statement of the committee of the American Society of Civil Engineers.

Senator KITTREDGE. Did it go through the rock core or did it go under the dam?

Mr. STEARNS. I have no exact knowledge of that; but I should assume that it would go through the core in places, because that rock core, built as it was built, would not have been water-tight.

Senator KITTREDGE. Did the engineers make a report on that feature?

Mr. STEARNS. They did not; but they did make a report that it had been built in this way, by which it would not be water-tight entirely.

Senator DRYDEN. Did you say that the specifications were not originally drawn by engineers?

Mr. STEARNS. They said that they could trace those specifications to an engineer, whose name they gave, in Connecticut, but that he said that he acted only as an attorney for the owners in writing them out, and that he wrote them just as they said to write them; that is, I presume, as far as the dimensions and general features of the dam were concerned.

Senator DRYDEN. Was the construction of it under the supervision of engineers?

Mr. STEARNS. It was stated by the committee that it was not. They said that they could not find that any engineer was ever responsible for either the design or the construction.

Senator MORGAN. Notwithstanding all that, it stood for nine years?

Mr. STEARNS. Yes, sir.

Senator TALIAFERRO. What is that ridge on the side of that dam?

Mr. STEARNS. That would be dump of rock, out there about—

Senator TALIAFERRO. About the water line?

Mr. STEARNS. So that the waves coming against it will not eat away the material of the dam. This lake will always be at a constant level, or nearly so, within 3 or 4 feet, and that is put there so that the waves will not eat away the material.

Senator TALIAFERRO. Does that extend along the entire inner face of the dam?

Mr. STEARNS. Yes.

Senator MORGAN. If you are through with your other statement, I would like to examine you about that map.

Senator HOPKINS. Senator, please let him go on until he finishes this, first.

Senator MORGAN. I had asked him to do that very thing, if you will take notice of what I said.

Mr. STEARNS. I have some more comparisons to make with dams that are under construction now, to show that the factor of safety provided for this dam exceeds that of dams now being built by others [exhibiting section of dam]. That is the Belle Fourche dam, in South Dakota, for which I think they advertised for contracts, and I think it has been let to contractors.

Senator KITTREDGE. Do you know what sort of a foundation that dam has?

Mr. STEARNS. Yes.

Senator KITTREDGE. What is it?

Mr. STEARNS. Clay.

Senator KITTREDGE. No, sir; it goes down to solid rock.

Mr. STEARNS. I think you are mistaken, sir. I will get the specifications if you wish; but I have read a complete description of it by the engineer, recently. I have also the plans here, which show that it does not.

Perhaps I had better continue my description first. That is a section taken from the contract plan at a place where the depth of water is 73 feet as against 85 feet for this Gatun dam.

Senator DRYDEN. Is the dam on the same scale as this proposed Gatun dam?

Mr. STEARNS. It is. The material underneath that dam is said to be an adobe clay except at the point where a creek passes. I think that is sufficient, if you have all seen the relative size of that to the Gatun dam.

Senator HOPKINS. That dam is drawn to the same scale as the Gatun dam, is it?

Mr. STEARNS. It is drawn to the same scale, but it has 73 feet of water against it instead of 85. I have here the profile of the valley of the dam site, which I will leave with the committee. It shows the borings which have been made through the earth down to what is called soft shale rock. This plan does not show the material that was encountered by those borings, but I have seen it elsewhere stated as being adobe clay, except in the vicinity of the brook, where there was some gravel, and that it was intended to remove—

Senator KITTREDGE. To what depth?

Mr. STEARNS. To remove the gravel entirely at this creek, where it is to be found; but otherwise it is intended to make only a small cut, which is 10 feet horizontally in width and something like 6 feet deep below the center of the dam, and also to take off from the present surface the soil. The amount of cutting is indicated, and is not to go to the rock, nor is there to be any core wall of any kind. This dam, by the way, is about 1 mile in length.

The CHAIRMAN. Is that an entirely earth dam?

Mr. STEARNS. Yes, sir; formed wholly of earth, to be put on and rolled in layers. There is, however, on the upstream side to be a protection of concrete against the water, so that the water will not wash the earth away. That is one of the designs of the reclamation service, passed upon by a number of engineers whose names are given; and they have good engineers on the reclamation service, and I have no doubt the dam is safe; but it has not the factor of safety that has been given to this other one.

Senator DRYDEN. How large a body of water presses against that dam? The question I would like to ask is: What effect does the size of a body of water have upon the width of the dam?

Mr. STEARNS. The size of the body of water has absolutely no effect. It is wholly a question of depth. If you had the Atlantic Ocean pushing against the dam, it would have no more pressure than a small mill pond. There is a matter that has to be taken into account sometimes, that if the dam breaks or gives way it may produce more disaster beneath, but it will not put any greater pressure upon the dam.

Senator KNOX. It is that law of hydrostatics that saves Holland from being submerged, is it not? The dikes there hold back the whole ocean?

Mr. STEARNS. Yes.

I have one or two other comparisons with existing dams which I would like to show you.

Senator HOPKINS. Before you leave that Dakota dam, it happens that one of the members of this committee represents South Dakota, and I judge from his suggestion that he did not agree with the statement that you made that that dam is upon clay, but he thinks it is upon rock. Now, what evidence have you to support your statement to the committee?

Mr. STEARNS. Here is a profile of the valley, with the borings going down through the earth to the rock.

Senator HOPKINS. And that map which you have there shows what, with respect to the material upon which the dam is located?

Mr. STEARNS. It does not tell the character of the material. I have read that elsewhere, that it is this adobe clay. That is the statement I read, not in an official report, because I have not seen one, but in an article written by one of the engineers connected with the dam for the engineering papers. And that is the inference that I would draw from this profile here, in which it shows these borings going down through, and by the ordinary methods of showing such things, the surface of the rock at a considerable distance below the surface of the ground.

Senator MORGAN. That South Dakota dam is still standing?

Senator KITTREDGE. It is not completed yet.

Mr. STEARNS. It is not yet built.

Senator MORGAN. Oh!

Mr. STEARNS. This is a recent design.

Senator MORGAN. That is a conjecture, then?

Mr. STEARNS. I am exhibiting that in connection with the statement that good engineers have designed a dam that has a much smaller section than this Gatun dam, as indicated there. I would not say that it would be equally safe to place that dam on this Gatun foundation, because that dam is to be built without having any subsequent settlement. It would not be safe to place that up here, and yet that is a comparatively small barrier that is to be placed by good engineers to stand a large pressure of water.

Senator HOPKINS. A head of 73 feet?

Mr. STEARNS. Yes.

Senator MORGAN. Are you prepared to give your adherence to the statement that that dam is permanent and will stay there?

Mr. STEARNS. Yes; with the materials as I understand them to be. That dam has a head of only 100 feet at the extreme bottom of the creek.

Senator MORGAN. That dam has an earth core through it, has it?

Mr. STEARNS. Yes; that has an earth core.

Senator MORGAN. And the dam that you are now exhibiting has been constructed?

Mr. STEARNS. It has.

Senator MORGAN. And by the sluicing process, except the earth core?

Mr. STEARNS. That is the statement that was made, that that was conducted by the sluicing process, but I think there is some question as to whether more than a part of it was so constructed. I know it was in part. The dam is the San Leandro dam of the water company which supplies water to Oakland, Cal., and it has a height of 120

feet, and the depth of water is about 115 feet. It is 120 feet for the full height of the dam, and I know the water rises nearly to the top of it.

Senator MORGAN. About what is the width of the dam?

Mr. STEARNS. Through from the water side to the downstream side, do you mean?

Senator MORGAN. No; right across it.

Mr. STEARNS. I do not know. I only know this cross section. This is the highest part of the dam. It is the highest earth dam in the world, so far as I am aware. It has a great deal more water against it than the proposed Gatun dam will have, and yet it is not nearly as massive.

Senator HOPKINS. What is the height of that dam?

Senator KNOX. He has just stated.

Senator HOPKINS. I was outside and did not hear it.

Mr. STEARNS. One hundred and twenty feet, with substantially 115 feet of water against it.

Senator HOPKINS. Yes.

Senator DRYDEN. There is no stone used in the construction of that dam?

Mr. STEARNS. Not at all. They put in selected earth in the center.

Senator DRYDEN. What do you mean by "constructed by the sluicing process?" I do not understand that.

Mr. STEARNS. It is a process that is used in the West and California—a good deal similar to the hydraulic process of mining in gravel beds; that is, a large hose is directed against some bank of earth, and the water and earth running down together are put into wooden sluices and carried on a down grade to the place where they wish to make a fill, and they build a small embankment, and then this sluiced material would be run into a pool of water, where the material would have time to settle, and then the clear water would run off, leaving the material in the dam, and that is the process which is proposed for the construction of the Gatun dam, except that in that case the water would not be brought down through sluices by gravity, but would be pumped up by these pumping dredges, such as those used on the—

Senator MORGAN. Like those that Mr. Bates is using at Galveston?

Mr. STEARNS. Yes; that same idea. A dam would be built down here somewhere—a low dam—and the dredges working below would pump the material over, and then it would settle, the coarser materials out here and the finer materials running up in this direction [indicating on map].

Senator DRYDEN. That material would run by gravity?

Mr. STEARNS. Yes, sir; if it only went a short distance at first they would keep extending their pipe and have a small dam so that the water could not go back in this direction [indicating on map], and the material would be deposited in the dam, making a very compact embankment; and it would be feasible to get the finer materials up toward the upper end of the dam, where the water-tightness is especially desired. It could be controlled in any way they wished, to deposit the material almost anywhere, and the material to be taken from the canal below Gatun is of a very good character for that purpose. It is composed of sand and clay for the most part, and that is good material to pump; that is, there are enough fine particles of clay to fill the interstices in the sand.

Senator MORGAN. Is that material obtained in the sea, any of it?

Mr. STEARNS. Out in the harbor I think the material is much finer, and would not be as good.

Senator MORGAN. Is the material to be obtained from the harbor?

Mr. STEARNS. No; it would be obtained from the canal between the Gatun locks and the sea—and Limon Bay. The minority report proposes building a canal 500 feet wide there, for several miles, and that would furnish the material. If it did not they would make it more than 500 feet wide—enough to get all the material desired for this dam up to about the water level.

Senator MORGAN. That is not the sluicing process, though?

Mr. STEARNS. It is exactly the same, except in one case the water runs down by gravity and in the other it would be pumped up from the sea.

Senator MORGAN. It would be pumped entirely, though?

Mr. STEARNS. I should say that there would be two processes, probably: First, for the more distant points, the dredging into scows, and then bringing the scows up to the lower side of the dam and dumping the material; and then applying the pumps and dredging and pumping it up into the dam.

Senator MORGAN. The great body of the dam there is—one hundred and how many feet is it?

Mr. STEARNS. One hundred and thirty-five feet, in all; but that process would not be carried above 80 feet, say.

Senator MORGAN. The great body of the dam leading down to the bottom of that yellow on the map there would be formed of material brought down the river?

Mr. STEARNS. No. Of course the engineers that have the work in charge can do as they please, because clayey material brought down there from a part of the Culebra Cut would be satisfactory for the construction of a dam; but it was thought that it could be put in cheaper and better to take the material from the canal between the Gatun locks and Limon Bay and pump it up into this dam from some such level as this.

Senator MORGAN. You take it from the body of the earth and put it on barges, and then put your pumps on the barges and pump it into this dam?

Mr. STEARNS. That might be done.

Senator MORGAN. What better plan is there than that?

Mr. STEARNS. The other plan that I suggested was to put it in the barges that had a hopper, so that they would dump just below the Gatun dam and have a pumping dredge constantly stationed down there, which would be pumping through pipes up into the dam.

Senator MORGAN. It would have to be handled twice, then?

Mr. STEARNS. Yes.

Senator MORGAN. It would have to be put on the barge first, and then it would have to be pumped into the dam afterwards?

Mr. STEARNS. Yes; but two results are produced: One is that you are digging a canal, and the other is that you are building a dam with the same material; so that one charge might be placed against the digging of the canal and the other charge against the building of the dam. That is the way we estimate it.

I have still another plan here for comparison.

Senator HOPKINS. What is the length of that dam that you are just leaving there?

Mr. STEARNS. I do not know the length.

Senator MORGAN. Is that the dam that supplies San Francisco with water?

Mr. STEARNS. That is not that dam. It is the Pilarcitos dam, and the depth is almost exactly 85 feet, the same as it will be at the Gatun dam.

Senator MORGAN. What is that central core there—earth?

Mr. STEARNS. No; that was carefully selected clay.

Senator MORGAN. Clay?

Mr. STEARNS. Yes; and it is carried down to the rock, and a connection there made with the rock; and yet you see the size of the mass of earth—because that clay in the center is earth, as well as the rest—which sustains 85 feet of water.

Senator MORGAN. What is that serrated, salmon-colored, underlying base?

Mr. STEARNS. That was marked on the plan I had as gravel, but as I have seen it on the ground, I think it is more nearly clay. I have seen this dam. By the way, it is perfectly water-tight.

Senator MORGAN. What is the material lying above that stratum?

Mr. STEARNS. The lower mark there?

Senator MORGAN. Above that; that mountain there, or that hill?

Mr. STEARNS. This is composed of clay, all of it.

Senator MORGAN. Hauled in or sluiced in?

Mr. STEARNS. Hauled in. It was selected clay, but not as good as this which was put in the center, which was carefully selected and puddled.

Senator MORGAN. What is the depth of the water on that dam?

Mr. STEARNS. Eighty-five feet.

Senator MORGAN. What is the width of the dam?

Mr. STEARNS. I should say, from memory, that it was about 1,200 feet.

Senator MORGAN. There is no weir in it, or wasteway?

Mr. STEARNS. Oh, yes. Not in this section of it, but in another part, cut through the rock, so that it would not interfere with this earth portion of the dam. They should be kept entirely separate.

Senator MORGAN. How long has that dam been standing?

Mr. STEARNS. It was built in 1865.

Senator MORGAN. Has it ever had to be replaced or repaired?

Mr. STEARNS. It was not built to that height in 1865, but was added to, so that this is a larger dam than the original dam. I think the original dam was 20 feet lower.

Senator MORGAN. They raised the head of water?

Mr. STEARNS. Yes, sir; and there was some trouble at the connection of the core wall with the rock. I say core wall; I mean the clay core.

Senator MORGAN. Yes.

Mr. STEARNS. At one end; and they dug down there and repaired it, and at the present time it does not leak at all. There were some leaks.

Senator MORGAN. Before it was repaired it had leaked?

Mr. STEARNS. Yes.

Senator MORGAN. But had not washed away?

Mr. STEARNS. That is correct.

Senator TALIAFERRO. What is the height of that dam?

Mr. STEARNS. About 95 feet, for the height of the dam itself above the ground, and 85 feet of water against it.

Then, on the San Francisco waterworks, another dam, the San Andres dam, which is almost exactly of the same dimensions, was built several years later, and it has never given any trouble, and is absolutely water-tight, as far as one can see.

There are, of course, many other large dams, but I think this is sufficient for showing how much smaller the dams are which actually hold water under the same head than that which is proposed. There is no doubt that the dam as proposed has from two to three times the dimensions that are necessary in that place for merely holding water. But the subject of dams has been under discussion so much at Panama that they are looked at with a magnifying glass, and besides that it seems worth while, within reasonable limits of cost, to make it absolutely safe, and also so enormous in size that an enemy or a mob could not quickly destroy it by making the water run over the top.

Senator MORGAN. I do not think any enemy will ever attack the canal on either side. It would be a foolish admiral who would take a fleet into that place to fight.

Senator HOPKINS. You do not look for a naval engagement, then, in the canal itself? (Laughter.)

Mr. STEARNS. No, sir. I would like to make a reference to one other point in the tests of filtration that is not exactly a laboratory experiment, if I may do so.

The CHAIRMAN. We would like to have you give us all the information you can, to-day, Mr. Stearns.

Senator MORGAN. I wanted to ask him a few questions on this map, and this blueprint.

Mr. STEARNS. If you will let me proceed just a moment, Senator, this is a very short statement.

Senator MORGAN. Yes.

Mr. STEARNS. I have said that in the north dike which I have built, the dam which I have built which is so similar to this Gatun dam, the water has not risen to the full height against it so as to give the 65-foot pressure that is expected. It has, however, risen one-third of his height, and, according to the laws of filtration, there should be one-third of the water coming through there. As a matter of fact there is no water coming through there that has ever been noticed. That is, it has been tested to one-third of the pressure. Second, last year, when the water rose on it to a height of 20 feet above the lower point, I had previously sunk in the dike an iron pipe and had measurements taken there frequently.

On the 31st of March the water was rising, and it was at this point against the dam (indicating on map), 7 feet higher than it was in the pipe inside. That is, the water did not rise in here as fast as it rose outside. (Indicating.) Two weeks later it had risen 7 feet more, coming up on the dam to about this point (indicating on map), and in here, in the two weeks, it rose only 1 foot. Still two weeks later, making it a month from the first observation, the water was up at a point corresponding to this point that I am indicating on the dam, about one-third of the height, and the water in the pipe, although it was at that time, say, 12 feet lower than the water in the reservoir, rose only 4 feet in these two weeks.

That is, in the course of a whole month the fall from this water in the reservoir to this point in the dam [indicating] was as an average about 10 feet, showing that not enough water would filter through moderately fine sand to fill up the interstices in that sand 200 feet away from the face of the dam.

There is just one other point, that at a point corresponding to this on the dike, when there was no water against the upstream side, the water from the rainfall alone——

Senator HOPKINS. Can you not make your statements in figures, so that the record will show them intelligibly?

Mr. STEARNS. At a point three-fourths of the way through from the upstream side of the dike the water stands in that dike higher than either on the upstream or the downstream side, showing that it is the result of the rainfall, and that the material, which is earth, is so nearly impervious that even the rainfall will not pass through it. Those observations were continued for three years, and it was shown that the fluctuations of the water in the ground in this portion of the dike corresponded to the fluctuations caused by the rainfall, and that they were caused by the rainfall.

Senator MORGAN. I would like to ask a few questions. I have been trying to get an opportunity all the morning to ask about something on this map that I want to get at. Is that a longitudinal section of the proposed Gatun dam that you have there on the wall?

Mr. STEARNS. We should call it a cross section, I think.

Senator MORGAN. Well, a cross section?

Mr. STEARNS. Yes; from the upstream to the downstream side.

Senator MORGAN. And the salmon-colored part of it represents the indurated clay?

Mr. STEARNS. No; the gray or blue part here at the bottom represents the indurated clay and the salmon-colored portion the alluvial material that has filled the gorges made in the indurated clay.

Senator MORGAN. Yes; and the yellow part is the dam superimposed upon that alluvial base?

Mr. STEARNS. It is.

Senator MORGAN. That dam was drawn, I suppose, in correspondence with this blueprint [indicating profile].

Mr. STEARNS. Yes, with the portion where the alluvial material has a depth of 200 feet on the east side of the island. It does not show the deeper portion where the porous material is on the west side of the island.

Senator MORGAN. This blueprint was accepted by both the majority and the minority as a correct illustration or demonstration of the actual condition of the soil on the axis of the proposed dam at Gatun?

Mr. STEARNS. Yes.

Senator MORGAN. Both sides acted on it?

Mr. STEARNS. Yes.

Senator MORGAN. The majority and the minority?

Mr. STEARNS. Yes, I think so; on that and other information.

Senator MORGAN. Well, they agreed upon this?

Mr. STEARNS. That was presented by the Isthmian Canal Commission, and we all accepted it as being correct.

Senator MORGAN. That is all I want to know. Therefore you must have acted upon it and agreed upon it.

I notice here at the bottom of the print that the first number is 250, the next is 500, the next is 1,000, and the next is 1,500. They seem to be divisions of 500 feet. That is for mere convenience, I suppose, of locating the borings and all of that matter?

Mr. STEARNS. Yes.

Senator MORGAN. In considering this map, do you go from left to right, or from right to left, in the study of it?

Mr. STEARNS. From the left to the right is the natural way.

Senator MORGAN. That means sections of 500 feet breadth in one direction, from left to right. These sections from the bottom of the map to the top represent the measurements down to and below the sea level?

Mr. STEARNS. Yes; they are numbered down from sea level and up from sea level.

Senator MORGAN. And this heavy line of white across there is the sea level?

Mr. STEARNS. Yes.

Senator MORGAN. The bed of the Chagres River, from the blueprint, is delineated as being 10 feet below sea level?

Mr. STEARNS. Yes.

Senator MORGAN. The bottom of the canal would be 40 feet below sea level?

Mr. STEARNS. Twenty.

Senator MORGAN. Twenty feet below sea level?

Mr. STEARNS. Yes.

Senator MORGAN. Is that the depth of the canal that you want to dig through there?

Mr. STEARNS. No; it is 40 feet below low tide, below Gatun. But that canal at that place would be all filled by the dam. That is the existing French canal.

Senator MORGAN. Oh! The existing French canal?

Mr. STEARNS. Yes, sir.

Senator MORGAN. The proposed canal, then, would be twice as deep—40 feet?

Mr. STEARNS. Yes; below low tide, making 41 feet below mean tide at that place or just below it.

Senator MORGAN. This is the French canal, and the canal that we propose to dig goes 20 feet deeper. Now, let me ask you, if you please, what is this outside, uppermost mark on the blueprint here?

Mr. STEARNS. That is the surface of the earth.

Senator MORGAN. As it is now?

Mr. STEARNS. As it now exists, yes, at the site of the dam.

Senator MORGAN. In the borings here on the west, I suppose—

Mr. STEARNS. That is east, that way.

Senator MORGAN. East?

Mr. STEARNS. Yes; that is the east side.

Senator MORGAN. In the borings from east to west you come across a deep gulch, reaching down to indurated clay to a depth of—

Mr. STEARNS. About 200 feet, or a little bit over.

Senator MORGAN. About 205 feet, according to this.

Mr. STEARNS. About 205 feet; yes.

Senator MORGAN. And at the top the width between this point and this [indicating] is a width of about how far?

Mr. STEARNS. About 1,800 feet.

Senator MORGAN. About 1,800 feet across?

Mr. STEARNS. About 1,800 feet at sea level from the indurated clay on one side to the indurated clay on the other.

Senator MORGAN. We will call that a geological gulch.

Mr. STEARNS. Yes.

Senator MORGAN. For the sake of convenience. Maybe it is not a proper description. But that geological gulch is 1,800 feet wide and 205 feet deep, if I understand it?

Mr. STEARNS. That is correct.

Senator MORGAN. That is filled up with all kinds of material that has been washed in there by the water, beginning at the bottom with clay or sand and then going up through timber, rotted in different degrees of decay, and so on, as described in the statements both of the majority and minority, going on until you get up to the surface of the canal?

Mr. STEARNS. To the surface of the ground, yes, sir; except that I should say that the timber would be an occasional thing, and hardly one of the general features.

Senator MORGAN. But it is an occasional hole in the ground that causes destruction, is it not?

Mr. STEARNS. Yes; but the timber would not be a hole in the ground. It would be timber, surrounded by sand or clay.

Senator MORGAN. I understand that timber is not a hole in the ground. You propose, if I understand you, to put your dam across this wide gulch here, superimposed upon this material that we have just been describing?

Mr. STEARNS. Yes; with some preparation of the site.

Senator MORGAN. With some cleaning off of the looser top?

Mr. STEARNS. A cleaning off of the looser material at the top, and if there should be anything else that needed to be taken off, it is supposed that it would be taken off.

Senator MORGAN. When constructed, the weight of that dam will rest for 1,800 feet upon this material that is delineated and demonstrated and proven by the borings that have been made?

Mr. STEARNS. It will.

Senator MORGAN. Yes; and you call that a safe dam for 1,800 feet?

Mr. STEARNS. I have not a question of it. I know it is safe.

Senator MORGAN. I am not questioning it. I am asking you the question.

Then, in proceeding from east to west, you come across a still deeper gulch of the same sort?

Mr. STEARNS. Yes; except that at the bottom of that gulch there is porous material.

Senator MORGAN. At the bottom of this gulch there is porous material?

Mr. STEARNS. Yes.

Senator MORGAN. Right at the bottom?

Mr. STEARNS. In the lower 58 feet, or possibly a little more than that.

Senator MORGAN. In the lower 58 feet is porous material, then?

Mr. STEARNS. Yes.

Senator MORGAN. How would you describe that with reference to its geological characteristics?

Mr. STEARNS. Why, it is sand and gravel that has been deposited without an admixture of clay, so that there are interstices, and it is, therefore, porous.

Senator MORGAN. Then it proceeds upward, as described here, and what is the width of that gulch at its top?

Mr. STEARNS. About 850 feet at sea level, between the indurated clay on one side and the indurated clay on the other.

Senator MORGAN. Across that second gulch there is the spillway to be constructed?

Mr. STEARNS. No, sir.

Senator MORGAN. I have not gotten to it yet?

Mr. STEARNS. Yes; you have passed the spillway.

Senator MORGAN. Where is the spillway?

Mr. STEARNS. The spillway is to be located in this indurated clay.

Senator MORGAN. In this indurated clay?

Mr. STEARNS. Yes. First, the cut would be made through there, down to sea level, or a little below, through which the Chagres could be turned while the earth embankments were being made over these two alluvial valleys.

Senator MORGAN. Now, then, what is the width of that spillway?

Mr. STEARNS. The diversion channel, which would be made first, is 150 feet wide.

Senator MORGAN. Yes.

Mr. STEARNS. But the spillway would have a much greater width.

Senator MORGAN. Yes. By the diversion channel you mean a channel dug temporarily to get rid of the waters of the Chagres River?

Mr. STEARNS. Yes.

Senator MORGAN. That diversion channel will be included in the spillway when it is completed?

Mr. STEARNS. Yes. The water that spills over the dam will go into the lower portion of that diversion channel and run out through this channel, made in the indurated clay and lined with concrete.

Senator MORGAN. So that it is a connected work, and the diversion channel and spillway, when the dam is completed, will comprise one part of the controlling works of the Chagres River?

Mr. STEARNS. Yes; you asked the width of the spillway. The total width is 810 feet.

Senator MORGAN. Of the spillway?

Mr. STEARNS. Yes.

Senator MORGAN. Which takes up the diversion works and applies them or appropriates them.

Then, to proceed to the spillway, we come to the gulch that you have just been speaking of?

Mr. STEARNS. Yes.

Senator MORGAN. Does your dam then run into the hills immediately?

Mr. STEARNS. It does; into hard land.

Senator MORGAN. At what point right here? Just indicate, please, on this blueprint.

Mr. STEARNS. Right there [indicating].

Senator MORGAN. That is about 5,800 feet long the dam would be, beginning here—no; it would not be; the dam would be from this point to this [indicating on profile]?

Mr. STEARNS. Yes; I should say about from here [indicating on profile].

Senator MORGAN. What would be about the width? You need not get it accurately.

Mr. STEARNS. The point you refer to is about 4,800 feet from the easterly end of the dam.

Senator MORGAN. And that would describe the width of the dam in that part of it?

Mr. STEARNS. Yes.

Senator MORGAN. That is the dam proper?

Mr. STEARNS. Yes, sir.

Senator MORGAN. That is the dam you have got delineated there [indicating map on the wall]?

Mr. STEARNS. Yes; except that for a portion of the way it is not like this. It is only in the alluvial valleys that it would have anywhere nearly this height [indicating on map].

Senator MORGAN. Will the locks be at the east or the west side of this blueprint?

Mr. STEARNS. At the east side.

Senator MORGAN. That would be over here, to the east [indicating on profile]?

Mr. STEARNS. Yes.

Senator MORGAN. What width will they occupy of excavation in order to set them in there?

Mr. STEARNS. I think about 330 feet as the bottom width of the excavation which may be made for them.

Senator MORGAN. For making the seats of the locks?

Mr. STEARNS. Yes.

Senator MORGAN. Do the seats of the locks adjoin—touch and form part of the dam? Are they connected together?

Mr. STEARNS. They are connected together, but the dam becomes so small at the location of the locks that I think the natural ground is above the water line; so that the portion of the dam would only be this superimposed part—this higher portion.

Senator MORGAN. Yes.

Mr. STEARNS. It is hardly the dam proper, and yet it is the embankment made so that the water can not possibly overtop it.

Senator MORGAN. This blueprint contains every notable fact that was considered by the Commission and Consulting Engineers, I will call them, in their examination of this Gatun dam?

Mr. STEARNS. No; they had the plans showing the topography of the section, and then there were, in addition, borings which I have already called attention to, made above this particular site, prior to our going down to the Isthmus, which in themselves were sufficient to show that this material was deposited in slow currents, and must, therefore, be fine material.

Senator MORGAN. Those additional borings you have mentioned support and sustain the conclusions, as you think, that were reached by the minority?

Mr. STEARNS. I do.

Senator MORGAN. That is, your proposition?

Mr. STEARNS. Yes, sir.

Senator MORGAN. They were done for that purpose, of ascertaining whether it was safe to rely upon the borings across the site of the dam, I suppose?

Mr. STEARNS. There were original borings which did not extend under the site of the dam, except to a limited extent, and we thought it desirable to have additional borings directly at the site of the dam, so as to verify the conclusions reached from the others.

Senator MORGAN. In your description of the formation of the earth you started out with the proposition that it was formed of rock, and then water in combination, and that the water washed the surface of the detritus of the rock down and formed this beautiful soil we are living on?

Mr. STEARNS. Yes. It formed first the geological gorge, as it has been called, and washed the fine material out to sea.

Senator MORGAN. And washed on until it made these beautiful gardens and hills and mountains that surround us?

Mr. STEARNS. What I said was that—

Senator MORGAN. It seems to me that you have omitted two prominent and very important factors in that matter. One is fire and the other is the coral insect.

Mr. STEARNS. Well, I think these actions took place while the valley was above the sea level, and the coral insect did not climb up to that height.

Senator MORGAN. You admit that volcanic action has had a good deal to do with lifting rocky material and melted rock and stones out of the bosom of the earth and throwing them out and scattering them over the valleys and hills, and so forth?

Mr. STEARNS. Yes, indeed.

Senator MORGAN. It has had a great deal to do with it. Is it not your opinion that this soft material that has become indurated (and from being called indurated, must have been soft and then made hard) was in a large part the debris or the ashes thrown out by the extinct volcanoes, of which there are many on that section of the Isthmus?

Mr. STEARNS. I should hardly want to put my judgment against that of anyone else as to how that was formed, but I think there is not much question but that, however it was formed, it was formed so that the gorges were the result of the action of the rivers flowing through them, which carved them out. I do not see how they could have taken that form by volcanic action.

Senator MORGAN. Would it not be a reasonable proposition or supposition that the coral plant had built a rim of stone around the sea; that the volcanoes had belched forth their ashes and their lava, and so on, and their fine material, and that the waters had washed these ashes down against that coral reef, and they had been deposited there and indurated by the process of time and by the attractions that exist between small particles of matter, either under water or above water?

Mr. STEARNS. I hardly think I could give an opinion of value on that point.

Senator MORGAN. You are a geologist?

Mr. STEARNS. Oh, no.

Senator MORGAN. You are not?

Mr. STEARNS. No, sir.

Senator MORGAN. I took it for granted that you were.

Mr. STEARNS. I said I had listened to explanations of geologists, and I have also had a geologist in connection with my own work.

Senator MORGAN. I am sitting at the feet of Gamaliel, getting infor-

mation. That is what I am trying to do. These ideas come into my mind because facts suggest them.

However this formation may have taken place, the indurated clay that you find at the bottom of these waters under the site of the proposed dam at Gatun has been built up there, has it not, in your opinion?

Mr. STEARNS. It was built up originally, and then was carved out by the action of water, to make these gorges.

Senator MORGAN. If the action of the water has carved out these gulches in here, and afterwards, by being resisted by the incoming sea water, has been deadened in its movement, so that it no longer carves out these deep places, is it not supposable that all the material that you find deposited in these two deep gulches here has been imported from mountains?

Mr. STEARNS. I think so; from the higher land.

Senator MORGAN. There is no doubt about that?

Mr. STEARNS. I do not think there is any doubt about it. It has come from the higher land, except that with tidal action backward and forward in there, there might have been some of it brought in from the sea, and shells might have grown there, or been brought in by these tidal currents, when the gulches were submerged below the sea level.

Senator MORGAN. Would not that process of scouring and carving out of this indurated clay have gone on until this day if it had not been for the action of the sea water in coming in and protecting it?

Mr. STEARNS. It is rather difficult to answer that question. Sometimes conditions are reached by which the heavier gravels will deposit in a rock gorge, so that the stream will flow over a bed of gravel and not cut any further down into the gorge. At other times the rock remains bare, and then the current of the river would at this day as well as at any day in the past continue to cut down into the rock.

Senator MORGAN. Is it the opinion of geologists that the eastern coast of Panama, I will say, is rising or falling?

Mr. STEARNS. I do not know.

Senator MORGAN. You have not looked into that?

Mr. STEARNS. No.

Senator MORGAN. Some statements have been made about it that have astonished and alarmed me by geologists. I do not pretend to be anything approaching that sublime state of civilization.

The CHAIRMAN. Would it be agreeable to you, Senator, to take a recess now until 2 o'clock, or 2.15?

Senator MORGAN. Yes. I shall not be here this afternoon, and I suggest that it is very necessary to have copies of this blueprint made for the use of the committee and the Senate. (Referring to blueprint profile, the original from which plate 12 was prepared.) It is the most important document that is in this whole case.

The CHAIRMAN. Very well.

Senator KITTREDGE. I agree with you, Senator, about that.

The CHAIRMAN. That seems to be the only copy that the Commission possesses. They sent it down to us and they say that it is the only copy that they have.

Senator KITTREDGE. They sent us what purported to be a copy, but was not.

Senator MORGAN. It is a very precious thing if that is the only copy that they have got and it should be printed at once. I hope the com-

mittee will pass an order that the chairman be requested to apply for permission to have it printed.

The CHAIRMAN. If there is no objection, that will be done.

Senator KITTREDGE. Mr. Stearns, Mr. Walcott telephones me that I am correct in regard to the foundation of the Belle Fourche dam. He says that there is a masonry core extending to the solid rock. I wonder why they put that masonry core down through that earth dam to solid rock?

Mr. STEARNS. Well, it is rather surprising that they do not show it on an official plan, on which they base their contract.

Senator KITTREDGE. I want to know what you have to say in answer to the question.

Mr. STEARNS. My information is that they did not.

Senator KITTREDGE. You gather it from these maps?

Mr. STEARNS. Yes; I do not see why they should, if that will answer your question.

Senator DRYDEN. These maps are published by the Government?

Mr. STEARNS. They are; and they are the plans which were submitted at the time contracts were asked for, and purported to be the official plans for the purpose of letting the contract. It seems to me there must be some misunderstanding.

Senator DRYDEN. The contractors' estimates were based upon the specifications and those maps, then, I suppose?

Mr. STEARNS. I have no doubt that they were.

(After an informal discussion concerning further witnesses to be called before the committee, a recess was taken until 2.15 o'clock p. m.).

AFTER RECESS. .

STATEMENT OF FREDERIC P. STEARNS, ESQ.—Continued.

The CHAIRMAN. Mr. Stearns, I think if you are ready to proceed now and make further statements to us, we are ready to have you do so.

Mr. STEARNS. Professor Burr, in his testimony on page 1540, after citing the case of the Mill River dam disaster, which I referred to this morning, makes this statement:

"Then, again, there is a reservoir which has been completed for the borough of Brooklyn, called the Milburn reservoir, which I have inspected in the course of my professional work for the city of New York, which was completed in 1893. That reservoir was completed under engineering specifications, with a puddled bottom, designed and put in place for the express purpose of preventing leakage. Yet when it was filled with 43,500,000 gallons of water it all leaked out in ten days, and that reservoir has never been in use since. That shows what water will do when it has a chance, even in so-called impermeable material."

Now, what is the condition, and how does that have any bearing upon the safety of the Gatun dam?

The facts are these, and they are taken from a public document entitled "The Brooklyn Water Supply," dated 1896.

The reservoir in question is a rectangular, artificial reservoir, having an area at high-water line of 48 acres. The ground on which it was built was the very porous sand and gravel found on the

southerly side of Long Island. In order to make the reservoir watertight, its bottom was to be covered with 2 feet in thickness of puddle, which it was provided in the contract should consist of 20 per cent of pure clay, to be mixed with materials found on the ground. It is stated elsewhere that in the actual construction more clay was used than was originally provided for.

On testing the reservoir it was found to be leaky, and an investigation was made in 1894 by Mr. J. J. R. Croes, who has since that time been president of the American Society of Civil Engineers. He made tests which, he says, "appear to establish beyond question that the whole bottom of the reservoir is a filter bed, pretty uniform in character, and passing water at the rate of two-tenths foot per day under a head of 3 feet, four-tenths foot per day under 6 feet, and six-tenths under 9 feet."

It will be seen from this statement that the conditions at the Milburn reservoir were entirely dissimilar from those at the Gatun dam. The material to resist filtration at the Milburn reservoir was 2 feet in thickness, while at the Gatun dam it is half a mile in thickness. If the comparison shows anything, it is that material which was not wholly impervious under a pressure of 9 feet of water permitted water to pass only at the slow rate of six-tenths of a foot a day.

I have said that the speed of filtration is due to the relation of the pressure of water to the thickness of the filtering material. Here was water that was four and a half times the thickness of the filtering material, instead of being one twenty-fifth of the thickness of the filtering material. The relations are so widely different that it has no bearing, and in any case the experiments show that the filtration was proportional to the head, which is the law I have tried to lay down to you, as proved by experiment.

The next instance which he cites to show that the Gatun dam may not be safe is that—

"Nothing is more common in the experience of waterworks engineers than to observe the underground flow of water through permeable or semipermeable material. In fact, many water supplies depend upon that flow, such as the borough of Brooklyn and many other cities that take their water from the deep underground sands or mixtures of sand and earth. You will find frequently small passages of water, some of them threadlike in magnitude, almost capillary passages, and from that up to passages that flow many gallons a minute."

I have at the hotel, but forgot to bring with me, a sample of this Long Island sand, which is extremely porous, and which will run almost like hour-glass sand when poured from one thing to another. It would be impossible for any passages to be formed in such sand. They would fill up. Besides, all of the information that we have with regard to the water coming into driven wells can be accounted for without the existence of such passages. The sand grains have interstices between them, and the water filters freely through those interstices to the wells—not through large passages, but through the interstices between the sand grains. It is obvious that no one has ever been down there to find out, and there is no reason whatever to think that such passages exist in sand.

Senator HOPKINS. At Gatun you mean?

Mr. STEARNS. At Gatun or anywhere else. I have had occasion, in building aqueducts and in building deep trenches in connection with the building of dams and dikes, to excavate in sand to great depths, and I never saw such a passage. Professor Burr speaks of it as being of most frequent occurrence. It is a thing that I have never seen, with a great deal of experience in those lines.

So that I think that any suggestion of underground passages in sand or sandy material or earth, especially when it is under a pressure of many tons to the square foot, is not based upon any correct observation of facts.

The statement made goes on to say:

"There are wells fed by such water on Long Island, and in our recent examinations for a tunnel under the Hudson River near New Hamburg we found such a passage by diamond-drill borings about 260 feet, if I recall the depth rightly, below the surface."

That might and certainly does give the suggestion that those are passages in sand. But I will call attention first to the fact that he mentions diamond-drill borings, which are only used in excavating through rock; and I also know that those borings made in New Hamburg (for I am connected with that same work) are borings into limestone, and it is common to find cavities in limestone. Those are found in the Mammoth Cave, for instance, where there are streams that flow through the limestone; and all over the country there are cavities in limestone. But it is not pertinent in the least to bring a statement of that kind here in connection with this alluvial material under the Gatun dam.

In answer to a question from Mr. Kittredge, "When was that, Mr. Burr?" Professor Burr goes on to say:

"Within three months—two months and a half ago; and those are not uncommon experiences. They are within almost, you may say, the daily range of hydraulic engineers or civil engineers engaged in that class of work."

It is a fact, if it had been so stated, that cavities in limestone are frequent; but the inference to be drawn from that is that it is a cavity in sand, and that that cavity might find its way through this half mile of dam and cause a hole through which water could flow with sufficient speed to wreck the dam, and I say that it is groundless.

In the next paragraph it is stated that "as an engineering guess, you might say that it probably would stand," but it goes on to say that there is grave danger. It seems to me it is decidedly an engineering guess that there is any possibility of passages.

I will not go into that matter further.

Senator HOPKINS. Your claim is that there is no guess about it, but that it is demonstrated to a certainty that the dam will stand as put there?

Mr. STEARNS. Absolutely; and it is the ignoring of the information obtained in the last fourteen years in regard to the movement of water through sands and other earths that makes any such statement as is made here by a member of the majority an engineering guess which is a very bad one.

Reference has been made in some of the testimony to an upward flow of water through some of the pipes driven down into this geological gorge at the Gatun dam. The principal flow occurred in pipes that extended down into that 58 feet in depth of porous mate-

rial in the deepest gorge—that 58 feet of material, or thereabouts, being under about 200 feet of impervious material.

The height of the top of the pipe when that flow occurred, as regards the level of the water in the river, is not given; but the surface of the ground at that point is 7 feet above the surface of the river, and probably the pipe stuck up somewhat farther at the time this flow occurred. I think it is fair to say that the pipe would probably have been at least 10 feet above the surface of the river, showing that in that pervious material at the bottom of the gorge the water was under greater pressure than that due to a height of 10 feet above the river.

Now, the river for 10 miles up to Bohio is at sea level; consequently that water could not have come from the river, because it would not filter 10 miles underground. Water does not do that unless it has a great deal of pressure to force it through; and it is a proof of the imperviousness of this blanket of 200 feet of material, because that water evidently came from some of the adjacent high ground, probably only in small quantities, and got under that 200-foot blanket of impervious material and could not find its way out into the river and relieve itself—that is, 10 feet more head or more pressure at the bottom of the gorge than that due to sea level did not force that water to relieve itself, because it was overlaid with such an impervious material.

The letter from Mr. Maltby sending these borings contained at the end a statement, after speaking of this upward flow of water, that it proves the impervious character of the 200 feet of material above it.

That porous material, which in the report of the majority is spoken of as if it might be almost anywhere under the section of the dam, is down under this blanket, so that there can be no communication with it. This salmon color here [referring to map] represents 200 feet, and the pervious material is below it; and that would require 200 feet of filtration down at that end, then filtration for half a mile through that pervious material to the other end, and then the rising of the water again through another 200 feet at this end; and that could not take place.

But I made one computation that, supposing (and this is a supposition or an assumption) that this impervious blanket were entirely taken off and the water had free access to that porous material at this point, and again the blanket were taken off at the lower end and the water had free access to that part, then the pressure of 85 feet acting upon that material, if it was as porous as the most porous sand that I was able to test, or as porous as the Long Island sands, or as porous as the coarsest gravel that I had occasion to test, would let through but 2 cubic feet of water per second. Of course that does not occur and will not occur, because the impervious blanket will stop it; but even if there were free communication, it would mean a quantity of water that could have no significance, either in the loss of water for canal purposes or in regard to the safety of the dam.

It is stated in the majority report (p. 47), among many suggestions as to the great gravity of the situation if the dams proposed by the minority should be adopted, that "the Board is therefore of opinion that the existence of such costly facilities for the world's commerce should not depend upon great reservoirs held by earth embankments

resting literally upon mud foundations or those of even sand and gravel. The Board is unqualifiedly of opinion that no such vast and doubtful experiment should be indulged in, but on the contrary that every feature of whatever nature should be so designed and built as to include only those features which experience has demonstrated to be positively safe and efficient."

I claim for the dams which are proposed by the minority that experience has demonstrated that they are absolutely safe and efficient, and that they have been carried in dimensions away beyond past precedent so as to make them doubly safe. The sea-level canal requires dams; and one proposition is a dam at Gamboa with a core wall of concrete extending from the rock upward at a place where the rock is 170 feet below the water level of the proposed reservoir. That suggestion is a suggestion that is far beyond actual precedent.

I have not any question but that there is actual precedent that would support the building of such a dam, and that it can be made perfectly safe. But while saying that they should not go beyond actual precedent, the majority, in the suggestion of a core-wall dam at that place, have gone far beyond actual precedent, for I know of no core walls in existence that are more than 125 feet high from the rock, while this is up to 170, if it is built away up to the surface of the water. I do not know whether they have decided to do that or not, but, anyway, the foundations are down 170 feet under water.

There is also the suggestion that that could be a solid masonry dam; but I never say any plans drawn with reference to one for that elevation, although plans have been drawn for one of a somewhat higher elevation which may have been used as a basis for that statement, that it would cost the same.

Senator KITTREDGE. May I ask just one question?

Mr. STEARNS. Certainly.

Senator KITTREDGE. You say 170 feet below water?

Mr. STEARNS. The rock at the lowest point on which the core wall would be based is 170 feet below the proposed water level.

Senator KITTREDGE. Below maximum water level—is that it?

Mr. STEARNS. That is the maximum water level; yes—the greatest height.

Senator KITTREDGE. You do not mean that the foundations of this dam are 170 feet below the surface of the water?

Mr. STEARNS. Below the surface of the water after it is raised to its highest level.

Senator KITTREDGE. That is the point.

Mr. STEARNS. Certainly.

The majority report makes only a very casual reference to the other dams which are to retain the reservoirs shown upon this plan. You will see them in blue toward the bottom of the plan. They are the dams across the Gigante and the Caño rivers, and the Gigantito.

An engineer, a member of the majority, in describing those dams in a preliminary way, suggested that they be made of earth without any core wall, and that they be carried 15 feet instead of 50 feet above high-water level in the reservoir; that they be made 50 feet wide on top instead of 100, as proposed here, and that they be given slopes of one on three, which are similar to those slopes extended down here and to this slope extended down here [indicating].

That is suggested in a place where there have been only the French surveys, where nobody has examined the sites, where the material has not been bored to find out its character nor the depth to the rock. He evidently did not have the fear of earth dams before his mind when he presented a plan of that kind.

Senator DRYDEN. How deep a dam did he propose?

Mr. STEARNS. I have a note here in his handwriting—the Gigante, 55 feet; the Gigantito, 60 feet; and the Caño, 65 feet. Those are depths of water down at the lowest point—that is, from the ground at its lowest point up to the water. Those figures are substantially the same as the figures for the proposed dams at the Pacific end, which I believe some members of the majority have thought might not be sufficient.

I should say that I think it is possible, in construction, by making deeper cuts through the summits, to diminish the depths at those dams, and there is no doubt they can be built safely; but I do not think that allowances were made for that in the estimates.

I merely wanted to call attention to this as showing that at that time at least one member of the majority did not have the fear of earth dams in mind.

I once had occasion to build a very small earth dam across a mill pond, where common gravel was dumped into the water, and there was no difficulty in pumping out the water on the downstream side of it. A good deal of water leaked through, but we never questioned the stability of that particular dam. I saw, within a month, an earth dam with some sheet piling in it, a cofferdam, on work with which I am connected as consulting engineer. It is work in which a tidal lock is to be built; and the water was coming through that dam so that the ground was wet for 10 feet up on the downstream side. The pressure at that time against the dam was about 40 feet. No one suggested that even with water coming through the dam there was any special danger.

However, I would not recommend a dam of that sort, without a larger factor of safety, for permanent work. It is rather an instance, though, that a dam of as small dimensions, I should say, as that Mill River dam, or very nearly so, with some sheet piling, which was not tight, as shown by the water coming through, held the water perfectly; and this dam proposed here has twenty times the thickness and four hundred times the strength, I should say. I think it would vary about as the square of the distances.

I think that concludes any statement I have to make with regard to dams.

Senator KITTREDGE. Would it be convenient for me to ask you here some questions about the dams?

Mr. STEARNS. Yes, sir.

Senator KITTREDGE. I notice that the maximum level of water is 85 feet.

Mr. STEARNS. Yes.

Senator KITTREDGE. Is that the maximum height at all seasons of the year?

Mr. STEARNS. It is expected that at the end of the rainy season the lake will be raised and held 1 foot higher than that, and in times of great floods it is expected that the water will go as high as eleva-

tion 87—that is, 2 feet above its height that is shown—but that would be only for a short time.

Senator KITTREDGE. What is the elevation of the spillway that you propose west of the hill?

Mr. STEARNS. The spillway is located on the central hill, and the sills of the spillway are to be 15 or 16 feet lower than the water at its normal level. The spillway gates correspond to those at the Chicago Drainage Canal, being almost exactly of the same dimensions.

Senator KITTREDGE. At what height will the water be before that spillway is used?

Mr. STEARNS. At the beginning of a very heavy rainfall, at a time when freshets would be expected, it is also expected that the gates would be opened, and there would be 15 feet depth of water going through the gates when opened, so that it would maintain the level of the lake without its rising, as a rule.

Senator KITTREDGE. Why do you have the surface of the water higher at any time than 85 feet?

Mr. STEARNS. If raised a foot at the beginning of the dry season, after the danger of freshets is over, there would be 1 foot more of water for lockage purposes during the dry season, so that it would be better to have it a foot higher than the normal level and draw it down during the dry season, perhaps, to the normal level or a little below; that is, there must be some fluctuation during the dry season, after the navigation gets to be large, in order to provide the water for lockage, and by starting a foot high it will prevent drawing it quite as low.

Senator KITTREDGE. What is the lowest point that it would reach in the dry season?

Mr. STEARNS. The lowest point, with a traffic equal to, say, 40,000,000 tons per year, would be 3 feet below the normal level.

Senator KITTREDGE. That is, down to 82 feet?

Mr. STEARNS. Yes.

Senator KITTREDGE. And you have calculated so that you can state positively that that would be the maximum height in dry seasons?

Mr. STEARNS. Yes; that would be not only in ordinary dry seasons, but in the driest season on record.

Senator KITTREDGE. How long do you figure that it would require to fill that lake after the works were completed?

Mr. STEARNS. I have not made any careful figures, but I think, about a year; but the filling would be done in part before the works were completed.

Senator KITTREDGE. What is the name of the reservoir with which you are connected?

Mr. STEARNS. It is known as the Wachusett Reservoir.

Senator KITTREDGE. Is that filled with water?

Mr. STEARNS. It is not at the present time.

Senator KITTREDGE. What is the height of water now?

Mr. STEARNS. Eighty-five feet.

Senator KITTREDGE. What is the height proposed?

Mr. STEARNS. One hundred and twenty-nine.

Senator KITTREDGE. The height you have given is measured from the lowest point in the reservoir?

Mr. STEARNS. Yes. It is at the height against the dam that is shown in this photograph—against the masonry dam, not against the earth dam [referring to photograph].

Senator KITTREDGE. I was there last November, so I am familiar with the location.

Mr. STEARNS. Yes, sir.

Senator KITTREDGE. I noticed when I was there, Mr. Stearns, that you had a masonry dam there.

Mr. STEARNS. There is a masonry dam across the main river, which is shown in the photograph to which I just called attention.

Senator KITTREDGE. And what are the dimensions of that dam?

Mr. STEARNS. The distance from the lowest point in the bottom of the rock gorge to the surface of the water is 189 feet. The width across the valley is 1,250 feet; but the main dam, as it is called—

Senator KITTREDGE. You are speaking now of the masonry dam?

Mr. STEARNS. Yes; the masonry dam is about 900 feet long, for what is called the main dam, that rises 20 feet above the water surface; and then there is an extension of that, where the height of the dam is very small, over which the water flows as a spillway, and that is about 450 feet in addition. It is carried upstream so as to give it a greater length than it would have if it went directly across the valley.

Senator KITTREDGE. What is the dimension of the dam up and down the stream?

Mr. STEARNS. At the water line it is about 25 feet thick, and 189 feet below the water line it would be about 189 feet thick.

Senator KITTREDGE. Why did you not construct that dam of earth?

Mr. STEARNS. An earth dam would not be appropriate, in the first place, because the spillway could not be kept away from the dam; and then it was a particularly appropriate place, I think, in which to build a masonry dam, as a second reason.

Senator KITTREDGE. When I was there I was told that the foundation was carried to bed rock. Is that true?

Mr. STEARNS. It was carried to bed rock; and then we excavated into the bed rock until we got a rock nearly free from seams.

Senator KITTREDGE. Why did you do that?

Mr. STEARNS. Why carry it to the rock?

Senator KITTREDGE. Yes.

Mr. STEARNS. Because a masonry dam should be founded upon rock.

Senator KITTREDGE. Was the character of the earth sufficiently stable to support a masonry dam?

Mr. STEARNS. I should say not.

Senator KITTREDGE. What is the character of the material there?

Mr. STEARNS. The greater part of it was a loose gravel. It was really very much mixed up. Some of it was fine sand. Then, on one side of the valley, there was a boulder clay, and on the other side, up the slopes, sand and gravel, loose.

Senator KITTREDGE. I noticed that you had some large earth dams there.

Mr. STEARNS. One of the large earth dams—if you have been along on the railroad—which was relocated is the dike that I speak of, which is similar to this. It will have water against it to a depth of 65 feet, and instead of being half a mile through it is a third of a mile through.

I might have called attention to one other thing, as to the similarity between that so-called dike or earth dam and this Gatun dam—that it is 2 miles long, while this is a mile and a half. The deepest boring there went down 289 feet, while the deepest boring here went down 258 feet.

Senator KITTREDGE. What are the foundations for that dam?

Mr. STEARNS. The different portions of it are built in different ways. In some parts there was a porous sand or gravel overlying the rock, and the rock was not far down. In those cases a trench was dug down to the rock. The rock was carefully plastered, and little walls were built on it to prevent the water from following along the rock. Then the excavation, which was somewhat like a railroad cut, was filled in with the surface soil stripped from the reservoir. We took that surface soil because it had the fine material in it and was not porous and because we wished to remove it from the reservoir to improve the quality of the water.

In other parts, where excavation could not be made to the rock, there was a deep cutting made, again like a railroad excavation or railroad cut, and sheet piling was driven in the bottom to cut off possible seepage through veins of sand that were not so fine as to be classed as impermeable. Then there was still another part of it and the highest part, where all that was done was to strip off the surface material, take out the stumps, and the fine material was laid right on the fine material underneath, precisely as is proposed here at Gatun.

Senator KITTREDGE. What is the height of the dam at the points you last mentioned?

Mr. STEARNS. There is 65 feet of water against it.

Senator KITTREDGE. And what do you mean by sheet piling?

Mr. STEARNS. Sheet piling consists, in this particular case, of three thicknesses of plank nailed together so that the center one would protrude beyond the planks on each side, making what is called a tongue, and at the other side of the pile there was a recess made by letting the middle plank set in, making a groove; and these planks were driven down into the ground, the tongue of one fitting into the groove in another, so as to make a continuous and approximately water-tight line of timber.

Senator KITTREDGE. What was the purpose of driving those piles?

Mr. STEARNS. It was, as I have already stated, because the excavation was not carried down to the wholly impermeable material, and as a safeguard this sheet piling was driven, perhaps on an average about 50 feet farther, to help cut off the flow of water under the dam.

The question of whether there should be sheet piling or not was dependent upon the character of the material found by the borings, and about one-third the length of the dam no sheet piling was needed, and the fine material rested directly on the fine material.

I will leave with you a pamphlet entitled "The Bohio Dam," by George S. Morrison, past president of the American Society of Civil Engineers. In it is a description of this north dike, by myself, with illustrations. Opposite page 264 there is shown an excavation, such as I have referred to, with the sheet piling in process of driving. This excavation was 60 feet deep. Opposite page 266 there is shown another view of the driving of sheet piling, and also a large-scale view of the bottom of the sheet piling, as it was being driven, with a water jet.

Opposite page 268 will be found a case where the trench was excavated to the rock and the rock is prepared to receive the fine material used for filling the trench. Still another cut shows the fine material in process of being placed in the trench.

Senator KITTREDGE. What is the height of the dam above the surface, above the point at which you went to solid rock?

Mr. STEARNS. It is variable, but I should say about 30 feet, as a rule. In some cases it was only 2 feet or 5 feet. It varied from practically nothing to 30 feet.

Senator KITTREDGE. To what extent did you make borings under the foundation of your earth dam at Wachusett?

Mr. STEARNS. In order to locate the dam at the place where the most impermeable material might be found, and to guide in its construction, there were made a very large number of borings. I do not recall how many, but I think the aggregate depth was something like 30 miles of borings.

Senator KITTREDGE. In what distance?

Mr. STEARNS. In 2 miles length of dam.

Senator KITTREDGE. And how far apart were the borings?

Mr. STEARNS. They were at first laid out in squares 200 feet apart over a very large territory, half a mile to three-quarters of a mile wide and 2 miles long. Then, having determined approximately the line of the dike, they were made about 1 foot apart; and then, to get to greater refinement immediately along the line of the dike, they were made 25 feet apart in squares.

Senator KITTREDGE. So that before you commenced the construction of that dam you made borings not exceeding 25 feet apart? Is that right?

Mr. STEARNS. In the vicinity of the dam; yes.

Senator KITTREDGE. In the foundation and its vicinity?

Mr. STEARNS. Yes. There was a special reason for that, I should say.

Senator KITTREDGE. I would be glad to hear that.

Mr. STEARNS. That the material was variable, and it was desirable to pick out the very finest material; while at the Gatun dam the material is homogeneous to a large extent; that is, it has been brought by a sudden process, which made it very much alike from one place to another in the distance of a mile and a half.

Senator TALIAFERRO. Can you ascertain that fact otherwise than by borings?

Mr. STEARNS. That it is homogeneous?

Senator TALIAFERRO. Yes.

Mr. STEARNS. I should say by borings together with a general study of what has been going on there; but mainly by borings, which seem to prove, by the entire absence of bowlders and gravel, that the material that has been deposited in that vicinity has been fine material; and fine material is impervious. I felt nearly as well satisfied that that was the case from the first set of borings as I did after the borings had been made directly across on the line of the dam, because there was hardly an exception to the rule in any one boring.

Unless there are more questions to ask, I will take up an entirely different subject.

The CHAIRMAN. Just proceed, Mr. Stearns.

Mr. STEARNS. There is one thing that may have been figured by your committee, or perhaps somebody else has presented it. It is the interest during construction on the lock and the sea-level canals. It is not customary to put the interest during construction into an estimate made by an engineer. He gives an estimate of the cost of the work, and I think it is generally the rule that appropriations are made of a certain amount of money to be expended on the work, and the interest appropriation is made separately.

I do not know how it may be in this case; but I think there is no question in anybody's mind that the cost of a work includes the interest during the period of construction, when the work itself is not in use.

I made figures for the sea-level canal and the lock canal on these bases:

I assumed in both cases that \$50,000,000 had been paid out in 1904. That, of course, is to the Republic of Panama and the New Panama Canal Company. Then, in the case of the lock canal, I assumed that it would take nine years for construction from 1906; and for the expenditures in 1905 I allowed \$14,000,000, and \$14,000,000 in each of the succeeding years.

For the sea-level canal I assumed the expenditure in 1905 as \$14,500,000, and \$15,500,000 in each of the next fifteen years. That makes the total as given by the majority of the Board of Consulting Engineers.

On that basis the interest on the sea-level canal, if completed in fifteen years (and that is the estimate of the minority, that it would not be completed in less than six years after the lock canal) would be \$66,297,000.

Senator DRYDEN. At what rate of interest?

Mr. STEARNS. Two per cent. I neglected to state that.

The interest on the lock canal, if completed in nine years, would be \$28,502,000. The difference in favor of the lock canal on these assumptions is \$37,795,000.

The CHAIRMAN. That is the interest during construction?

Mr. STEARNS. Yes; that is the difference between the two plans.

The CHAIRMAN. Yes.

Mr. STEARNS. Now, if the time for constructing the sea-level canal should extend to eighteen years the interest account would amount to \$88,532,000. Deduct, as before, the interest on the lock canal, \$28,502,000, and the difference in favor of the lock canal is \$60,030,000.

The cost of the lock canal, including interest and the payments to the Panama Canal Company and to the Republic of Panama, would be \$219,000,000. The grand total of similar payments in the case of the sea-level canal, using the cost as estimated by the Board of Consulting Engineers, and assuming fifteen years for completion, would be \$363,000,000; and the cost of the sea-level canal, including some items based upon the cost as estimated by the Isthmian Canal Commission, and assuming eighteen years for completion, would be \$410,000,000.

I think that has considerable weight in the type of canal that should be adopted.

The CHAIRMAN. If you will hand that statement to the stenographer, it will be printed.

(The statement referred to is as follows:)

RELATIVE AMOUNT OF INTEREST DURING CONSTRUCTION ON LOCK AND
SEA-LEVEL CANALS.

In both cases assume that the interest is at 2 per cent, compounded annually.

Assume in both cases an expenditure of \$50,000,000 in 1904.

In the case of the lock canal assume a total expenditure for the ten years from 1905 to 1915, inclusive, of \$14,000,000 per year, making a total of \$140,000,000 for construction.

For the sea-level canal assume the expenditure of \$14,500,000 in 1904 and of \$15,500,000 in each of the next fifteen years, making a total of \$247,000,000 for construction.

Interest on sea-level canal if completed in fifteen years.....	\$66, 297, 000
Interest on lock canal if completed in nine years.....	28, 502, 000
Difference in favor of lock canal.....	37, 795, 000
<hr/>	
If the time for constructing the sea-level canal should extend to eighteen years, the interest account would amount to.....	88, 532, 000
Deduct, as before, interest on lock canal.....	28, 502, 000
Difference in favor of lock canal.....	60, 030, 000
The cost of the lock canal, including interest and payments to the Panama Canal Company and the Republic of Panama, would be.	219, 000, 000
The cost of the sea-level canal, including interest and the above payments, based upon the cost as estimated by the Board of Consulting Engineers, and fifteen years for completion, would be	363, 000, 000
The cost of the sea-level canal, including interest and the above payments, based upon the cost as estimated by the Isthmian Canal Commission, and eighteen years for completion, would be	410, 000, 000

Senator ANKENY. Mr. Stearns, have you prepared a relative estimate there showing a comparison of the sea-level and the lock canal in regard to maintenance?

Mr. STEARNS. I have; yes. I will take that up next. I will say that I have not actually made the figures, but I will take up some of the statements that have been made as affecting the maintenance of the two canals to show, I believe, that they are not in any way warranted.

The lock canal will have only three places where a force of attendants will be required—namely, the locks and dam at Gatun, making one place; the locks at Pedro Miguel, and the locks at Sosa; also the waste way at Sosa, which is not far away from the locks.

The sea-level canal will have about nine such places—namely, the Sosa locks, the seven meeting places (they are not shown in the plan of the majority, but I think it is understood that they are needed, and they are placed about 5 miles apart), and the Gamboa dam and power plant.

The force required at the locks will undoubtedly be larger, of course, than the force required at the meeting places. Do I make myself clear as to the meeting places? Has that matter been discussed here?

Senator KITTREDGE. Yes.

The CHAIRMAN. I think we understand that, sir.

Mr. STEARNS. But at those meeting places there will have to be probably three shifts of men, and enough men to take the lines as they are passed out from the ships as they come along. The force at the locks—I am not so familiar with that work as are other members of the minority, but there has to be the force to take the lines as they are passed out as the ship comes up to the pier there, just as it would come up to the pier at the meeting places. Then there has to be the force for operating the gates and the power plant, but the power-plant force would be no greater than that at the Gamboa dam, I presume.

The total force required for operation would be larger on the lock canal I have no doubt, but it would be very largely offset by the greater number of places in the sea-level canal.

The other big item is dredging.

It is unnecessary to discuss the dredging in the harbors, because that would be the same in each case and would not enter into the comparison; and it is the dredging, then, practically between the shore lines on the two sides that needs to be considered.

In some of the testimony there is a very surprising statement which has been made, tending to show that in the case of a lock-canal plan the silt brought down by the upper Chagres will not deposit in the portion of the Gatun Lake above Gamboa, but will pass through this portion of the lake, and then the greater part of it will be dropped in the channel of the canal all the way down to Tavernilla. This statement is to be found on page 1570 of the testimony.

Senator KITTREDGE. That is Mr. Burr's statement, is it not?

Mr. STEARNS. Yes.

The portion of the lake to which I refer is this portion from the extreme upper end down to Gamboa. There comes into this portion of the lake the Chagres River at its upper end and also a number of tributary streams.

When we were on the Isthmus there was furnished to us a table, which is shown in this blueprint, which gives the number of cubic feet of water in the reservoir above Gamboa at different levels. It is given for elevation 80 and for elevation 90, and to get elevation 85 I have averaged those two amounts.

The size of that reservoir is 4.94 square miles, and it holds 1,905,000,000 cubic feet of water, equal to 70,500,000 cubic yards.

The flow of the Chagres, as given by General Abbot, averages for the year about 3,200 cubic feet a second; for the rainy months of the year about 4,000 cubic feet per second; in high freshets, such as occur in most years, it would reach 25,000 cubic feet a second. In still greater freshets, which occur perhaps once in three years, it may reach 50,000 cubic feet a second; and in phenomenal freshets it would go up higher, possibly to 75,000, or perhaps higher than that.

It is a subject of easy computation, knowing those quantities of water coming into the lake, to ascertain how long it would take to push the water in the lake out ahead of that coming in, provided it were all pushed out. And I find that, taking the average rate of flow for the year, the water would be pushed out in one hundred and seventy-six hours. At the average rate for the rainy months it would be pushed out in one hundred and thirty-two hours. In the case of high freshets, in twenty-one hours. In the case of the still

higher freshets that I have mentioned, in ten and one-half hours; and in the case of a phenomenal freshet there would be seven hours required for the crowding out of that water.

Senator KITTREDGE. Under what plan?

Mr. STEARNS. The lock plan.

There is also susceptible of computation, knowing the length of time, the number of hours, required to go 6 miles from the upper end of the lake to Gamboa, to determine what the average rate of flow is; and that figures out, taking the average rate for the year, at three one-hundredths of a mile an hour. The average rate for the rainy months is five one-hundredths of a mile an hour. During high freshets it would be twenty-nine one-hundredths of a mile an hour.

In anything further I have to give you you will have to remember that it only comes at intervals of years. Even then, with the still higher freshets, it would be fifty-seven one-hundredths of a mile an hour and with phenomenal freshets eighty-six one-hundredths of a mile an hour—that is, even the extreme conditions there would not produce an average velocity, if all the water were pushed out ahead of the water coming up, as much as a mile an hour; and that is the freshet of once in fifty years, which does not need to be counted at all.

The statement has been made that the water coming in at the upper end would find its way through this lake, following the line of the present river, with all its crooks, and consequently would bring the silt down and distribute it down to Tavernilla and leave, I suppose, the clean water on the sides in the lake. That is based on observations which are quite frequently made when rivers overflow their banks in case of freshet, and the water, for instance, in a river that has a height of 10 feet to its banks overflows to a depth of 2 or 3 feet, only a small proportion of the depth. On the Mississippi River it might be a case of overflowing 10 feet where the depth from the banks down to the river is, say, 50 feet—that is, the river will control the rapid current when there is only a slight rise above the top of its banks.

But in this case the river up to its banks is more nearly 10 feet and the amount that the water is raised above it is 20 to 30 feet. So that the flow will not be governed by a channel which is submerged to so great a depth and is comparatively insignificant.

I know that would be the case, because I made a study of that matter last September, making cross sections at various places; and the channels that are now there are insignificant and would not guide the course of the current to a great extent.

On the other hand, there are some bays in here which would not furnish their full effect in depositing the silt; but it is beyond all question that the silt will properly deposit in the portion of the lake above Gamboa. In that part of the lake will be deposited all of the gravel, all of the sand, and all of the fine silt, except, possibly, that in case of freshets some slightly discolored water will go beyond. But it means that practically none of that will ever get into the canal.

It is equally true that we have these other streams coming in. This is a very small sketch plan. You can see that the distance of one mile is the distance between those dots; and these smaller streams come in sometimes 2 miles away, sometimes a mile, and I think there is only one case within half a mile, except in the case of the Obispo, which comes in a short distance below Gamboa.

In that case it was the plan of the minority to build an embankment parallel to the canal down to an island that is shown between mile 29 and mile 30; and then there would be an estuary more than a mile long, in which the silt from the Obispo could be deposited. That embankment is not included in the estimates, because it was not thought that it would cost anything. The water would be of the same height on each side of it, so it is not a dam; and it was thought that the material from the Culebra cut could be deposited there without any extra cost.

Senator KITTREDGE. Would it be in the nature of a breakwater?

Mr. STEARNS. There would be no waves to affect it. It is a dividing embankment, which may be of fine rock or almost anything sufficient to prevent any great current of water passing through into the canal, and forcing the flow of the Obispo to come in a mile below where it would naturally come in if the embankment were not placed there.

I think it is absolutely fair to say that no dredging whatever would be required on the lake portions of the lock-canal plan.

I will call attention to the other side of the case, as stated in the testimony of Professor Burr, on page 1504. He says:

"The smaller streams—and there are quite a number of them, but all very small—would be taken directly into the volume of the canal in the ordinary way, quite an ordinary procedure in canal construction, but instead of pouring directly into the prism of the canal they would first pass through a basin built on one side of the canal prism, so that any sediment which they might bring down in floods would be held there, and the water would flow over a weir into the canal."

Do I make it clear? This is the sea-level canal now [reading]:

"In that way no sediment whatever from the Chagres River or from any of its tributary streams would be brought into the canal. It would be entirely kept out, and it would also be kept out of the canal on the Pacific side from the small streams—because they are only small streams on that side—in a precisely similar way."

The testimony goes on with a question from Senator Morgan:

"So that the water would find its way into the canal, but the sediment would be left behind in these basins?"

"Mr. BURR. The sediment would be left behind in these basins."

In the first place, the report of the majority did not provide any basins in which the sediment could be deposited.

Senator KITTREDGE. Is that an expensive proposition?

Mr. STEARNS. May I go on and come to that matter later?

Senator KITTREDGE. Certainly.

Mr. STEARNS. The report of the majority is this:

"The tributary streams, whose beds at point of junction with the canal are considerably above the prism of the latter, will be discharged over masonry-stepped aprons or through metallic discharge pipes, or these beds will be sloped and lowered so as to prevent objectionable currents at junction points. The means for the accomplishment of these results are such as are in common use on nearly all important canals.

"During three-fourths of the time these streams discharge an insignificant amount of clear water. When they are in flood they will bring down some silt, and it is recognized that the maintenance of the navigable canal channel will require a small amount of dredging."

Now I will answer the question which has been asked as to whether these basins would be expensive.

The testimony is to the effect that a basin containing 70,000,000 cubic yards of water above Gamboa is insufficient for these streams that enter above that point, including the Chagres River. The small streams, so called, which enter below, bring in, in the aggregate, considerable water. General Abbot, in papers which he has written on the hydraulics of the Panama Canal (see the report of the Board of Consulting Engineers, p. 187), has determined that the flow past Gamboa is 65 per cent of the flow at Bohio. That is, if this is 65 per cent coming in here then there is 35 per cent of the total quantity at Bohio coming in from these tributary streams. That is, half as much water comes in between Gamboa and Bohio from those streams as comes in above. But the majority have provided for turning part of this water away by reversing the flow of the streams so that the quantity would be considerably smaller.

The basins ought to have as large a size in proportion to the flow of these streams as this portion of Gatun Lake in proportion to the streams entering there. To give them that size, they should contain about 22,000,000 cubic yards of water. But these come in quite high above the sea-level canal; and to provide 22,000,000 cubic yards of water space in those basins would require the excavation of more than 22,000,000 cubic yards of earth. For instance, if a basin is required for the Obispo, which is one of the large streams coming in close by the canal, that is all rock at that place. I do not see how a basin could be built which would be proportionately large to this one above Gamboa, except by the excavation of a great amount of rock there, or by building another one of the dams.

Probably the basins could be formed more easily by the building of dams than in any other way—by increasing the number of dams on the sea-level plan. If that dam were built at present, it is needless to say, perhaps, that it would flood the Panama Railroad. But it is not a small thing. It would go up into the millions of dollars to attempt to provide as good a settling basin as is provided by the upper end of Gatun Lake; and that is said by the majority—

Senator KITTREDGE. You do not mean Gatun Lake, do you?

Mr. STEARNS. Yes, sir.

Senator KITTREDGE. Oh! Under the lock plan?

Mr. STEARNS. Under the lock plan. I am comparing the two plans. The lock plan has this great receptacle for silt; and to produce artificially receptacles for silt for the streams coming into the sea-level plan would require many millions of dollars. And yet the statement is made here in the testimony that the silt from here would come down and go into the lock canal, while not a particle of sediment would get into the sea-level canal.

The fact that sediment would get into the sea-level canal—for, practically, it is impossible to keep it out—means that there would be dredging. With a canal having a depth of only 40 feet, and especially where the bottom is in rock, if that depth is to be maintained at nearly 40 feet, it would mean cleaning the material off as soon as it had gathered to the depth of 1 or 2 feet, say, and would reduce the depth to 38 feet immediately above the surface of the rock, which would be very expensive. That is, a canal in rock that is going to

have silt come into it ought to be excavated to a greater depth than 40 feet.

I have not made any figures to cover the case, but it would seem to me that the dredging on the sea-level canal would be a large item; and I think it can be proved by the detailed figures such as I have given, and not by an engineering guess, that the material would all deposit in the case of the lock-canal plan.

Those are the items that make up the bulk of the maintenance. Of course there is the government of the Zone and other things that are equal in both cases.

Senator DRYDEN. You have not allowed in this statement anything for the interest on the difference in the capital cost of the two plans?

Mr. STEARNS. Not in this statement. If that were allowed the capital cost of the two plans should be made including interest during construction, which would make a much wider difference in the cost between the two than the mere work of construction, and that is easily figured by anybody who wishes to do it.

Senator DRYDEN. That would be a permanent difference, of course?

Mr. STEARNS. It would.

Senator HOPKINS. Have you reduced to figures the difference in cost of maintenance of the two types of canal?

Mr. STEARNS. No; but my judgment is, as far as judgment is worth anything—my engineering guess is that it would cost as much to maintain the sea-level canal as the lock canal.

The CHAIRMAN. Mr. Stearns, have you any statement to make in reference to the other dams on the lock plan?

Mr. STEARNS. I think they are governed practically by the same laws and rules as the one that I have described in so great detail. The material under the La Boca dam I think is even more impervious, although we have not as many borings. It may be more muddy. That was anticipated; and the dam on its upstream side was carried out a long distance in this direction [indicating] so that there would be enough weight on this material lying outside of what would be the natural shape of the dam to prevent the mass of the dam from crumbling down into the material and causing a flow. I do not think there is as much sand over there, and sand is the element that produces friction and prevents a flowing of the material under heavy weight. There is no question about the ability to so load any such material as that that it will not flow when displaced.

At the other sites the rock is very near the surface. At the Ancon-Corozal dam I think our borings showed in no case rock more than 4 or 5 feet down, although they were not sufficiently frequent to show that it might not be deeper at other places.

Testimony has been given with regard to the future transformation of a lock canal into a sea-level canal, and it is not in accordance with the report of the majority or the action of the whole Board of Consulting Engineers. I do not know just where to find the testimony, but I think it has been given, that if a canal were built as a lock canal it would never be transformed to a sea-level canal.

Senator KITTREDGE. Do you favor that?

Mr. STEARNS. I think it will be done some time.

Senator KITTREDGE. Do you favor it?

Mr. STEARNS. The question is too indefinite for me to answer yes

or no. I think I will explain so fully that my proposition will be clear.

My belief is this: That by building a lock canal at the present time the United States is not precluded from having a sea-level canal at some future time.

Senator ANKENY. Would it not be very expensive to transform a lock canal into a sea-level canal eventually?

Mr. STEARNS. Yes; but I think there might be a great difference in opinion as to the time when that "eventually" is coming. Mr. Bunau-Varilla, who came before us, suggested that that was the proper way to get a sea-level canal very soon in the near future, and the Board of Consulting Engineers did not agree with that view, because they thought a sea-level canal transformed from a lock canal would cost more than a sea-level canal built immediately.

Senator TALIAFERRO. That is true, is it not?

Mr. STEARNS. That is true.

I would like to read you the statements which are made here in the report of the majority, and which are fully concurred in by the minority. They are as follows:

"1. That it is possible to turn any lock canal which it [the Board] has considered into a sea-level canal without interrupting the traffic upon it."

That it is possible to do it.

Senator HOPKINS. That is the judgment of the entire Board?

Mr. STEARNS. Of the entire Board.

I will omit the second one, which says that it is not financially possible to do it now, which we all agreed to. [Reading:]

"3. That if a sea-level canal is to be constructed in the near future it should be built directly, without first building a lock canal."

We were all agreed upon that—that if a sea-level canal is wanted in the near future, it should be built without building a lock canal first.

"4. That the date for developing a sea-level from an existing lock canal would be so remote, and that there would be so little difference in the time and cost of the transformation for different types of lock canals with a common summit level, that the design of a lock canal should not be controlled by the view that it is subsequently to be so transformed."

The view that I hold was very well expressed by one member of the majority of the Board, when he said that he thought it could be done; and we all agreed to that. He said: "When it is desired the financial difficulty will have disappeared."

The lock canal is estimated by the minority to be capable of taking care of a traffic of 80,000,000 tons a year. I think the price per ton on the Suez Canal is at least a dollar.

General DAVIS. It is 7½ francs now.

Mr. STEARNS. That would be a dollar and a half. Eighty million tons—or, let me say, 60,000,000 tons, instead—would represent \$90,000,000 a year of revenue. If \$90,000,000 a year of revenue were being obtained from that canal, the question of whether it cost another year's revenue or two years' revenue would not be of importance. Fifty or seventy-five years from now, if a sea-level canal is wanted, there is no reason why it should not be constructed; and I think the

statements that I have read show that that is the judgment of the entire Board, although statements have been made to the contrary here.

Senator ANKENY. Do I understand, Mr. Stearns, that the transformation can be carried out without interfering with the traffic on the canal? Is that what you have decided?

Mr. STEARNS. That is the judgment.

Senator ANKENY. Of the engineers?

Mr. STEARNS. Of the engineers. But let me say this: That as a step in the transformation, under the plans that are now proposed, I have no doubt that additional locks would be built. At least two locks at Gatun out of the three would be built anew with reference to the transformation; so that there would be three locks for use before the transformation had proceeded very far, so that when working in one there would be two for traffic.

But the additional locks probably would not mean, throughout the whole length of the canal, more than an additional \$25,000,000; and looking to the time when I have suggested that this is to be done—that is, when the traffic gets up to sixty or seventy million tons a year—it will be entirely unimportant whether it costs an extra \$25,000,000 or not.

Senator ANKENY. But I understand that your conclusion was that this transformation might take place and be completed without disturbing the traffic on the lock canal?

Mr. STEARNS. Yes; that is the unanimous opinion of the Board.

Senator DRYDEN. You have no doubt read the testimony of one engineer here, who, in giving his opinion, gives one directly and diametrically opposed to yours upon this point?

Mr. STEARNS. Yes.

Senator DRYDEN. He has testified, in effect, that if we built a lock canal now, we shall always have a lock canal; that while it might be physically possible to transform a lock canal into a sea-level canal, the price would be prohibitive.

Mr. STEARNS. I do disagree with that entirely; because, as I have stated, if a traffic is reached equal to 60,000,000 tons, and that is the occasion for transformation—that they want to accommodate more traffic than can well be carried through a lock canal—it seems to me that money would be no object. It seems clear that that would be the case, with \$90,000,000 a year earnings; and that is what it would be at the rate of \$1.50 a ton.

Senator DRYDEN. Have you made any figures as to the cost of transforming a lock canal into a sea-level canal?

Mr. STEARNS. Yes. It was estimated that one could be transformed from the 85-foot level proposed for the lock canal to a sea-level canal that was 150 feet wide for \$208,000,000. Now, it seems to me absolutely certain that that would not be done, because it would transform it into a canal that was not as good for traffic as the lock canal. But we also made figures as to what it would cost to transform it into a sea-level canal 300 feet in width.

Senator KITTREDGE. Do you mean at the surface of the water or at the bottom?

Mr. STEARNS. At the bottom. I think I have not the figures with me—are they in the report?

General DAVIS. No; they are not in that book; they are in those detached memoranda or records.

Mr. STEARNS. I should say, from having rather an uncertain memory on that particular point, that it was about \$340,000,000.

General DAVIS. Yes; it was somewhere in that neighborhood. That is about right.

Senator KITTREDGE. Why not build the sea-level canal now?

Mr. STEARNS. To build it to that width, which would make it better than a lock canal, would require not only this \$247,000,000 that is estimated, but, according to the estimates of the Isthmian Canal Commission, another \$87,000,000, and take many more years.

Senator KITTREDGE. Are the only objections you have to a sea-level canal the matters of time and money?

Mr. STEARNS. I will have to qualify my answer by saying that I think a sea-level canal if made from 300 to 400 feet wide would be far preferable to a lock canal—assuming, of course, that due care was taken to keep the silt and tributary streams in such a condition that they would not interfere with the operation of the canal.

Senator KITTREDGE. That could be done, could it not?

Mr. STEARNS. I think it can be done. It is only a question of money and time.

Senator TALIAFERRO. Do you think, Mr. Stearns, that a sea-level canal of the width of 300 feet could be built there for \$87,000,000 more than the estimate of the Board for the 150 or 200 foot canal?

Mr. STEARNS. I have no information upon that point that is at all definite except the statement of the Isthmian Canal Commission.

Senator TALIAFERRO. Have you looked into that question at all?

Mr. STEARNS. Not enough to give an opinion.

Senator TALIAFERRO. Did the Board look into it in considering the type of the canal?

General DAVIS. Only to the extent you speak of in regard to the transformation.

Senator SIMMONS. How long would it take to build a 300-foot sea-level canal, Mr. Stearns?

Mr. STEARNS. There is one way of getting a rough estimate of the time required to build the canal, and that is by the amount of money that can be practically expended in a year. I found that \$15,500,000 would have been expended in a year for a sea-level canal completed in fifteen years. At that same rate, from five to six years additional would be required to spend an additional \$87,000,000. That is rather a crude estimate, but it would not be so very far from the truth.

Senator TALIAFERRO. So you have a way, Mr. Stearns, of estimating the time, but no way of estimating the amount?

Mr. STEARNS. Do you mean the amount in dollars?

Senator TALIAFERRO. I say you have a means of estimating the additional time that would be required to construct this 300-foot canal, but you have no means of estimating the additional cost of such a canal?

Mr. STEARNS. I have stated that the Isthmian Canal Commission has given an estimate of the cost which seems to me reasonable, I will say; but I have made no figures, so that I can not tell exactly.

Senator ANKENY. Has it not been considered that this widening of the sea-level canal might go on without interruption of traffic?

Say that it was built upon plans that appear in the majority report. Assuming that it is constructed on a basis of 150 feet, might it not be widened to 300 feet without disturbing the traffic that might go on in a 150-foot canal? In other words, those betterments might go on without disturbing the traffic in the the first proposition?

Mr. STEARNS. I think they could to some extent—that is, where the material was sand and gravel that could be dredged; and especially toward the ends of the canal, that could be dredged and taken out to sea quite readily. In the Culebra cut, to carry that widening process at all fast with the sea-level canal and traffic through it would be troublesome. If many scows or barges were employed to carry the material, it would interfere considerably with the traffic through so narrow a canal. Of course it could be done in the dry above water level. I think it could be done.

Senator ANKENY. Without disturbing the traffic?

Mr. STEARNS. Well, I do not think it could be done entirely without disturbing the traffic.

Senator ANKENY. I mean materially.

Mr. STEARNS. But without very seriously disturbing it.

Senator HOPKINS. Can a lock canal be transformed into a sea-level canal without disturbing the traffic seriously?

Mr. STEARNS. I should think it could; and I had better give my reason, I presume.

Senator HOPKINS. Yes.

Mr. STEARNS. The portion to be widened from 200 feet to a greater width at the Culebra cut is only 4.7 miles long. That would not require the removal of nearly as much material, and the barges could be towed down into Gatun Lake, and as soon as they got into the wide channel—500 feet wide—they would not interfere with navigation. Moreover, the lake is deep enough so that barges, with their small draft, could go almost anywhere in it. They could be taken to places—and there are many of them—in the bays where the material could be dumped, making quite a short haul for the material that would come from the Culebra cut. There are places down there where a large amount of material could be dumped. It would be more convenient than taking it away out, as in the sea-level canal, to the sea; and if it is not taken out to the sea any material that is dredged or taken below the water level will have to be hoisted up in some way to where it will not run back into the canal.

Senator HOPKINS. I do not want to interfere with your plan of developing your ideas on the subject of the two different types of canal, but before you get through with your statement, Mr. Stearns, I would like to have you go back to the Gatun dam and speak of the locks there. The contention has been made that there is not room enough there to establish a flight of three locks, and I want to hear from you fully on that subject before you get through. I do not want to interrupt you.

Mr. STEARNS. I will state it now; it is just as well as at any other time. I saw the draftsman at the Panama Canal Commission—

Senator HOPKINS. Before you make that statement, let me ask this question: The plan that is proposed by the minority provides for a flight of three locks of 900 feet each, I think?

Mr. STEARNS. Yes; 900 feet of usable length.

Senator HOPKINS. Yes; usable length. Now, the statement was made by Mr. Bates, and I think some others, that the space is not sufficient to provide for locks of that character.

Mr. STEARNS. The statement probably arose from a draftsman's error in this plan of the Gatun dam, where the locks are shown shorter than 900 feet of usable length.

Senator HOPKINS. Now, what paper is that? I ask so that it can be identified by the reporter.

Mr. STEARNS. Plate 11. The estimates were all made upon a large scale drawing which I saw this morning, and that large scale drawing shows locks with a usable length of 900 feet.

If this plan had been correctly drawn, these locks would have been lengthened by an amount which I do not exactly remember, but which I should say was about 200 feet. The borings show that those locks could be moved upstream not less than 300 feet if desired, and still have a rock foundation for the locks themselves, but not for the approach wall. The approach wall, as shown on this plan, does not have a rock foundation, and there is no chance whatever for it. It was never contemplated.

That approach wall was to be built on material filled out as a foundation, according to our plans, and on that was to be placed a timber crib which can rest on a foundation which is not absolutely solid; and on the top of the timber crib was to be a concrete capping. It is just the same kind of construction that is used at the Soo Canal. There is also room for moving the lock farther on the downstream end. There is no question whatever, so far as we know, as to the feasibility of building locks of the length contemplated.

Senator KITTREDGE. What do you mean by that—"so far as you know?" Do you not know all about the foundational conditions there?

Mr. STEARNS. The borings at the Isthmus were made in connection with a plan which is somewhat different from the one now proposed. It was a plan for two locks, and they were located in a different position. As a result, we have not borings at the lower end of the lock, but there are borings near by.

Senator KITTREDGE. How near?

Mr. STEARNS. The nearest one is about 150 feet from the lock wall, and I should say about 700 feet above the lower end of the lock. The greater number of those borings showed quite generally a depth of from 20 to 30 feet down to the indurated clay. They were so uniform that Mr. Maltby in the letter made the statement that "the clay seems to be found here about 20 or 30 feet below the surface." The excavation toward the lower end of the lock will necessarily be 85 feet deep; and there is hardly a question but that indurated clay will be found far above that level, so that the lock can be placed upon the indurated clay. We did not have, in the short time at our disposal, an opportunity to settle every detail point, but there seemed to be no reason to doubt that additional borings would show that that was all right. It certainly shows by the high ground there that it is not alluvial material.

Senator KITTREDGE. Are there any reasons in favor of the proposition which you can suggest?

Mr. STEARNS. In favor of the statement that indurated clay would be found?

Senator KITTREDGE. That you can go down there and get a satisfactory foundation?

Mr. STEARNS. Why, I think so. The fact that borings along there showed similar results would indicate that very strongly—that is, since they showed that the indurated clay was within 20 or 30 feet of the surface, we are quite certain that it would be found certainly within 80 feet.

There is one point here, outside of the line of the lock, however, where a boring went down to a great depth; and it might be found that the clay would be deeper at some point where the lock is situated. I do not think that would be fatal with regard to this lower lock. I am now consulting engineer on a work where a tidal lock is being built on piles. I do not think I should want to suggest piles for this plan, but I have no doubt—

Senator KITTREDGE. How many cubic yards of masonry go into the lock structure? It is 3,000,000, is it not?

Mr. STEARNS. I think very likely; I should think it might be 3,000,000 in all the locks the whole length of the canal.

Senator KITTREDGE. That would require a good solid foundation?

Mr. STEARNS. The solidity of the foundation would depend upon the height of the walls at that particular place.

Senator KITTREDGE. You would have to have a good foundation all along the lock structure, would you not?

Mr. STEARNS. Certainly.

Senator KITTREDGE. In order to have a good foundation you would have to have it go all the way along, would you not?

Mr. STEARNS. Yes. It is more important to have a very resistant foundation in some places where the walls are high than in other places where they are lower. Some difference could be admitted.

Senator KITTREDGE. In the operation of these heavy gates and machinery you would require absolutely solid, firm foundations, would you not?

Mr. STEARNS. You must indeed have them; the thing must remain immovable.

Senator KITTREDGE. Absolutely immovable?

Mr. STEARNS. Yes; but the pile foundation that I am speaking of in connection with a lock that is being built on work that I am now connected with is also an absolutely immovable foundation for that lock.

Senator KITTREDGE. What is the size of the lock to which you now refer?

Mr. STEARNS. This is about 350 feet long, 45 feet wide, and has a depth of 16 feet at low tide.

Senator KITTREDGE. Can that properly be compared with the lock at the Gatun structure?

Mr. STEARNS. It is not nearly as heavy.

Senator KITTREDGE. What is the difference between them in weight?

Mr. STEARNS. I could hardly guess at that.

Senator KITTREDGE. What is the difference in cubic yards necessary to construct the locks and the necessary structure connected with them?

Mr. STEARNS. I do not think the cubic yards have anything to do with it, because that spreads over a great length of territory. The

question, as I have already said, is one of height of walls, and I do not know those figures well enough to tell you.

Senator KITTREDGE. What is the weight of the gates?

Mr. STEARNS. I do not know; I did not figure those at all.

Senator KITTREDGE. What is the weight of the machinery necessary to operate the gates?

Mr. STEARNS. I do not know. That was the part that I was not calculating upon.

Senator TALIAFERRO. Speaking of those borings at the Gatun dam, Mr. Stearns, at what depth did I understand you to say water flowed up through the pipes?

Mr. STEARNS. At the point of most considerable flow, where it came up through a 2-inch or a 2½-inch pipe and flowed over the top to a depth of an inch and three-quarters, that water came from more than 200 feet below the sea level, and the top of the pipe at that time was probably not less than 10 feet above sea level.

Senator TALIAFERRO. Did the borings show water at different depths as they went down?

Mr. STEARNS. That material is saturated from top to bottom. It is down below sea level; it could not help being, and there was a small flow, where the water just trickled over the sides of the pipe, at several points. They are all noted on that blueprint. I think there was shown to be about a quarter of an inch of depth of flow over the pipe as it rose. Do you catch my meaning?

Senator TALIAFERRO. Yes.

Mr. STEARNS. The water flows up from the pipe, and then goes over, and they measured the amount by the depth on the edge of the pipe as it flowed over.

Senator TALIAFERRO. So that there was more or less flow of water through the pipes at all of these borings, below what depth, would you say?

Mr. STEARNS. I did not say at all the borings; there were a few instances.

Senator TALIAFERRO. Only a few?

Mr. STEARNS. Only a few. They can all be picked out on that blueprint there.

Senator TALIAFERRO. I will ask you to pick out those depths—at what depth water first appeared, and to what depth it went.

Mr. STEARNS. In order to distinguish these, I will give what are called the stations. At station 20, plus 81, the water flowed one-quarter of an inch above the top of the casing from a point 32 feet below sea level down to a point 63 feet below sea level.

At Boring 23 plus 37 the water flowed with one-quarter of an inch depth on the pipe at a point 72 feet below sea level. At this same boring the water flowed with a depth of one-quarter of an inch from 170 feet below sea level down to 190 feet below sea level.

At Station 22 plus 40 the water flowed with a quarter of an inch depth over the casing from a point 124 feet below sea level.

At Station 27 plus 30 the water flowed with a quarter of an inch head above the casing from a point 151 feet to 169 feet below sea level. This is immediately over the indurated clay.

At Station 52 plus 67 there was a flow of one-quarter of an inch above the casing from 41 feet below sea level to 65 feet below sea

level; and from that same pipe a flow of one inch above the casing at 215 feet below sea level. This is in the porous pocket that has been referred to so many times.

At Station 54 plus 51 the water flowed $1\frac{1}{4}$ inches over the top of the casing from 192 feet below sea level down to 229 feet below sea level. This is also water from the porous pocket.

At one other point, at Station 56 plus 48, about 125 feet below sea level, there is a slight flow of water noted; no measurement.

That is all.

Senator TALIAFERRO. What distance do those several stations that you have enumerated cover across the site?

Mr. STEARNS. Including the high ridge in between the two, the greatest distance from the first one that I mentioned to the last one is 3,600 feet.

Senator KITTREDGE. Leaving out that hill, the central point?

Senator TALIAFERRO. Taking out the ridge.

Senator KITTREDGE. Within the distance where the borings were actually made?

Mr. STEARNS. If I divided it into two parts, one in one alluvial valley and the other in the other, I could tell you better.

Senator TALIAFERRO. State it in your own way, Mr. Stearns. Just adopt your own method.

Mr. STEARNS. In the alluvial valley of the island the most distant points at which water rose through the pipes were 650 feet apart; and in the alluvial valley west of the island the most distant points were 381 feet apart.

Senator KITTREDGE. Were there any borings made in those places that water did not appear?

Mr. STEARNS. Yes, sir.

Senator KITTREDGE. How many?

Mr. STEARNS. Five in the valley east of the island——

Senator HOPKINS. The island is the pocket you have spoken of in your previous testimony, is it not?

Senator TALIAFERRO. It is in the gulch.

Mr. STEARNS (continuing). And one in the other valley.

Senator KITTREDGE. In the valley which you first described those five places were a very short distance below the surface; they were not very deep, were they?

Mr. STEARNS. The shortest is 32 feet and the next shortest is 72 feet.

Senator KITTREDGE. You have said that in that pocket there were five. Three of those five borings went to what depth—the shortest borings? It is over at this side where you struck the indurated clay, is it not?

Mr. STEARNS. There is no water there.

Senator KITTREDGE. Well, those are the three of the five that you described?

Mr. STEARNS. As having no water?

Senator KITTREDGE. Yes.

Mr. STEARNS. Yes.

Senator KITTREDGE. Now, to what depth do those go?

Mr. STEARNS. I was going to say that those that showed no water as a rule were the shorter borings.

Senator KITTREDGE. In other words, when you got down to any depth you were almost certain to find water. Is not that the fact disclosed by that report?

Mr. STEARNS. I should say that it was, at some point in the depth.

Senator TALLIAFERRO. These borings are immediately under the proposed dam?

Mr. STEARNS. Yes. I might add that I do not think the water being found there has any significance.

Senator TALLIAFERRO. That is, of course, a question.

Senator HOPKINS. Why?

Mr. STEARNS. Because water is very generally found under such circumstances. It falls on the adjacent upland and gets down into the ground under a very slight increase of pressure. It may be only a barrellful or two barrellful, or something of that sort—not a great quantity—and if a pipe is driven it is very likely to come up. A number of these pipes were driven from a point more than 10 feet above the level of the Chagres River there, and if they had been driven from a level that was down near the river probably all of them would have shown some flow. If the water seeping in from the adjacent high ground to that will not find its way underneath there, it is almost sure that there is no more pressure in the interstices of any sand that is found than the pressure that is due to the head of the river above.

Senator HOPKINS. But the quantities are so infinitesimal that it can have no material effect on the land?

Mr. STEARNS. Oh, not at all; they mean nothing. They have no significance, except this freer flow that was found to exist in this deep pocket, and water would not flow so freely as to come up through 200 feet of pipe and when it got to the top rise an inch and a half above the top of the pipe if there was not free water-bearing material to bring it in at that rate. There is free water-bearing material, I think, down in that pocket that is 200 feet down.

Senator DRYDEN. Mr. Stearns, I want to revert again to the usable length of these locks. That is an important matter and there is a conflict of testimony in regard to it. Mr. Bates had a model here the other day, and by placing there a model of a ship relatively 788 feet long, I think, he showed that there was a space of only 2 feet left in the usable length of those locks. A subsequent witness, an engineer, testified that while the usable space in these locks from outer gate to outer gate was 900 feet long, the usable space from inner gate to inner gate was only 790 feet long.

I would like to ask, in the first place, whether these inner gates were the result of a second thought on the part of the engineers?

Mr. STEARNS. The inner gates, or the double gates, that you refer to were placed only on the summit level; and they are a safeguard against the possibility of any ship, by some mistaken notion—some mistaken understanding of signals—going through the locks, and making, as it might with a single lock, a breach through which the water of the lake could run out, causing disaster; and with the provisions which have been made of these double gates, and also a movable dam inside, there is a still further precaution, the double gates being probably sufficient for anything that might happen. They were provided for safeguards—not as an afterthought, but as a part of the design.

Senator DRYDEN. They were a part of the original design?

Mr. STEARNS. They were a part of the original design.

Senator DRYDEN. Then why is it reported to us that the usable length of those gates is 900 feet when it is really only 790 feet.

Mr. STEARNS. Well, it is not the case.

Senator DRYDEN. And yet two very prominent engineers have been misled.

Mr. STEARNS. I do not know whether they have seen the working drawings at the office of the Canal Commission on which those were based. As I have already stated, if they had taken it from this plan here, where the draftsman, in reducing those large drawings to a small scale, so as to put them on this plan, made a mistake, then they would find such results as you speak of.

Let me take, first, the two lower locks where there are no double gates. In those the distance from lock gate to lock gate is 955 feet; and the gates will swing so as to leave 900 feet of usable length. I have not verified this by actually swinging them myself, but that is what I was told continually. I looked at the plans this morning, and that is what they show. I did not try swinging the gates, but there was 955 feet of gross length, working out into 900 feet of usable length.

Now let us come to the upper lock. There are double gates at the upper end of it, and there are double gates at the lower end of it. At the upper end this measurement of 950 feet goes from the inner one of the two gates, but in measuring down to the lower end of that summit-level lock it was assumed that only one gate would be used if there was a ship 900 feet long; that is, the precaution that is provided against all ordinary operations would not be provided in the case of a ship 900 feet long. But on the contrary, the rule would be, I should assume—of course I do not know what the rules will be—but the rule should be made, with a ship that goes in there, with only a single gate, that it should be taken in with a tug and should not turn its propeller, and that it shall have its lines out and go in slowly. You know that if a 900-foot ship is in existence, going through that canal, it is not probable there would be any more than two or three in a year. The great bulk of ships are small. The big ship is the very rare thing. I think there are only six or seven or eight ships in existence—you probably have had that testimony before you—which are of this large size, and those are all on the North Atlantic route.

I have had a drawing made which might illustrate this to some extent. That [indicating drawing] shows a lock with 955 feet gross and 900 feet net length, in which the largest ship now in existence is placed. Here is one lock gate; there is the other lock gate, and that is the spare room. That is the *Baltic*. The *Carmania*, the biggest Cunarder that was launched, I think, last year—anyway, the largest now in service—which is 676 feet long by 73 feet wide, is shown by this black indication, and it shows how much leeway there is in a lock of that size.

Coming down to something that is not quite as large, here is the *St. Paul*, a boat that is well known as being one of the American Line, and that was used in the Spanish war as one of our fast scouts. It is one of the express steamers across the Atlantic, and you can see what length there is to spare with a ship of that kind.

Then I have put in here something more on the ordinary size of ship. There are four in the lock. That is based on dimensions given me for the largest coastwise steamers; and I take it that it covers also the steamers that go from New York to Cuba and to Panama and to Mexico—the largest size. The smaller ones, if they were put in there, might be packed in six at a time; and those are the ships that would ordinarily come to the canal.

It seems to me to be no disadvantage worth consideration—that it is not worth the additional money to lengthen that upper lock so as to take in this enormously large ship (which would come very rarely, if at all) with both gates closed.

Senator DRYDEN. But, Mr. Bates, these safety gates, if they are ever needed for a protection, would be needed in time of danger. Now, is not the time of danger the time when you have a big, powerful vessel, one of the largest and longest vessels afloat, in there? Is not that when the safety gates are going to be needed, if ever?

Mr. STEARNS. I do not think so; because if those vessels come only two or three times a year, there is no reason why an additional fifteen minutes should not be taken to carry them in, and the requirement be made that they shall not turn their propeller wheels. There is no danger to the gates if boats are put in slowly.

Senator DRYDEN. Then, if they are not to be used except when they are needed as a protection against the greatest danger, why are they there at all?

Mr. STEARNS. Because you have practically the same danger from a ship the size of the *St. Paul* that you would have from one of those largest ships. To make speed in getting in and out of those locks it is desirable, judging from the experience of the Soo Canal, that they should be permitted to use their own propellers and to go in with their own power. Now, that could be done, we will say, with a thousand ships in a year, and 2,000 or 3,000, whatever the number might be; and yet you could follow another rule of not permitting the very large ones that came only three times a year to do so, without interrupting the traffic of the canal.

Senator DRYDEN. Now, let me understand. Is it true that the usable space between these inner gates is but 790 feet? Is that true?

Mr. STEARNS. I do not think it is.

Senator DRYDEN. No; I understood you to say—

Mr. STEARNS. I think it only takes out 80 feet.

Senator DRYDEN. I understood you to say previously that you thought it was a draftsman's mistake.

Mr. STEARNS. I thought it might result from that. It is possible that between the inner gates it may be only 790 feet. I do not think it would need 110 feet between gates. I do not see why it should.

Senator DRYDEN. This is a matter, of course, which you are not in any way responsible for, but the query occurs to me, if we are misled in an important matter like this—and this is certainly a very important matter, as affecting this lock plan of canal—whether we have any security whatever in depending upon other measurements and drawings made here by the draftsmen?

Mr. STEARNS. Well, I do not think that the work of the draftsmen in procuring plans ought to be brought up against the consulting engineers, because these plans would never be used as a basis for construction.

Senator DRYDEN. I am sorry you did not understand me to say a moment ago that you were in no way responsible.

Mr. STEARNS. I so understand; let me say against the plan, rather than the consulting engineers; that is, nobody will ever work from this smaller plan to determine the size of the locks. They will take the figures as given by the consulting engineers if that plan is adopted, and the large scale drawings, which are correct, and not be governed by some little sketch of a plan which should have been right but is not.

Senator DRYDEN. Yes; that is true. But as regards the work of this committee you must bear in mind that we have to go by the drawings, maps, and plans submitted to us; and we have been asked and urged by competent engineers here to reject this plan, this being given as one of the reasons why we ought to reject it. Of course I ought not, perhaps, to press this as against you, because you are in no way responsible for it, but I want to ask one more question in connection with the location of the lock there.

It has also been said here that these locks could not be lengthened. Now, I understand you to hold the contrary view, and certainly one or two other engineers hold the contrary view.

Mr. STEARNS. I do not see how these particular locks could be lengthened. What would be done, in my opinion, if larger locks are needed, would be to build a third row of locks at this location [indicating]. If that [indicating] did not give you sufficient length right immediately beside these locks, then put them farther into the hill, where there is a greater length.

There is no reason that I can see why an additional lock should not be built there at any time when they are desired. They could be built in the beginning, adding roughly, I should say, \$30,000,000 to the cost, if the locks were made 125 feet wide by 1,200 feet long and giving three locks. But I think the information that we have shows that what is planned is sufficient for the present, and probably will be sufficient for thirty or forty years. Then the proper time will come for building larger locks if by any chance it should be found that enough ships of larger size wished to go through by the Isthmus.

This is what has been done in the past experience in canals. In the Soo Canal they built first a small lock. They could not have afforded the lock that was built more recently. Then they built another size; then the third lock, and now they are considering another larger one. That is much less expensive than it is to provide for a hundred years in the future.

Senator KNOX. What is the length of the largest lock at the Soo now; do you know?

General DAVIS. Eight hundred feet.

Mr. STEARNS. Eight hundred feet, I am told.

Senator DRYDEN. Can you suggest how we can get absolute information as to the usable length of these locks?

Mr. STEARNS. The information is the statement of the consulting engineers as to what they propose; and the only question, it seems to me, that might arise, would be whether there had been any mistake by which something should be made longer. Of course that is easily remedied by the expenditure of a very small sum; but there is no mistake, in my opinion. It was very carefully done by a good

engineer connected with the drafting work there under Mr. Noble's immediate direction.

Senator KNOX. The estimate made by the minority was for locks with a usable length of how many feet?

Mr. STEARNS. Nine hundred feet.

Senator KNOX. Of a usable length of 900 feet?

Mr. STEARNS. Yes.

Senator KNOX. And the estimate of cost is based upon having locks with that much usable length?

Mr. STEARNS. Yes; and you will understand that in the upper lock that usable length is obtained only by having the inner gate open for a very great ship.

Senator KNOX. I quite understand that; and then the lower locks would have an actual usable length of 900 feet all the time?

Mr. STEARNS. Yes.

Senator KNOX. And the upper lock might be shorn of the use of how many feet?

Mr. STEARNS. I think it is 80 feet.

Senator KNOX. What would be the greatest length of vessel which could occupy that upper lock with both gates shut, both the safety gate and the regular gate?

Mr. STEARNS. As nearly as I know, it would be 820 feet.

Senator KNOX. And there are no vessels of that length now?

Mr. STEARNS. There are none in existence at the present time.

Senator KNOX. No. Now, even assuming that in the next twenty years they grow to such enormous length—of course when you enter the lock the entering gates are not closed until after the vessel gets in the berth?

Mr. STEARNS. No; they should be closed, I will say, immediately as the vessel goes in.

Senator KNOX. At once; yes, sir; I understand. But there is nothing to prevent the use of a tug to control the motions of the vessel, so that she need not go in under her own power?

Mr. STEARNS. That is correct.

Senator KNOX. So that with a tug and with proper check lines you could bring the vessel up to within a very few feet of the lock gate with absolute safety, could you not?

Mr. STEARNS. Yes.

Senator HOPKINS. Even under that condition, where you used a tug and safety lines, you could throw open the inner gates and have the entire 900 feet, could you not?

Mr. STEARNS. I think that is what was stated.

Senator HOPKINS. Yes.

Senator KITTREDGE. Suppose you put a ship into a lock in the manner that Senator Knox has indicated, and stop it just before you reach the safety lock; how would you push it ahead? Would you use a windlass, or what?

Mr. STEARNS. Generally it would be done by a tug behind it.

Senator KITTREDGE. Pushing it?

Mr. STEARNS. Yes; or there might be winding machinery. That has been suggested, and a great many drawbridges and locks have apparatus to wind them ahead with a winch.

Senator KITTREDGE. Was that the plan that you had in mind?

Mr. STEARNS. I never have studied it at all for this place. I have for the lock that I am connected with elsewhere.

Senator KITTREDGE. That is a little bit of a lock, is it not?

Mr. STEARNS. It is not very large. It will take the ordinary small steamers that run on the coastwise trade.

Senator KITTREDGE. It is comparatively small, is it not?

Mr. STEARNS. It is, decidedly; or else these others are comparatively large.

Senator KITTREDGE. What is the largest ship now on the stocks?

Mr. STEARNS. It is said to be 800 feet by 88 feet by 36 to 38 feet draft. I have seen it differently stated. In fact, I have seen it stated as a little shorter than 800 feet.

General DAVIS. Seven hundred and eighty-eight feet.

The CHAIRMAN. Do you mean the Cunard ship?

Mr. STEARNS. Yes, sir.

The CHAIRMAN. She is either 780 or 788.

Mr. STEARNS. I think there is no expectation that such a ship will ever get through the canal; or, at least, the United States will not be very much interested in having it. The United States could not obtain that ship in case of war, I believe, as it is subsidized to the British Government.

Senator KNOX. Even if you wanted 50 to 100 feet more of usable length in those locks, as I understood you a few moments ago, there is no reason why the locks can not be built to get it?

Mr. STEARNS. No.

Senator KNOX. It is only a question of a little more money?

Mr. STEARNS. It is a question of money. It would cost, judging from some very preliminary estimates, about \$4,000,000 more to make those locks 100 feet wide with 1,000 feet usable length than to make them 900 by 95.

Senator KITTREDGE. I understood you to say to me that there was a question about getting a good foundation, too.

Mr. STEARNS. I do not think so. I think there is plenty of room for it.

I prepared some sections a short time ago, of which I have photographs here, showing one of those Cunarders that have not yet been launched, and I should acknowledge my indebtedness for the picture of the Cunarders to the Scientific American. I have shown them in sections of canal that are 150 feet wide, as proposed by the majority, and with sections 300 feet and 500 feet in width, as proposed by the minority. I have not included the 200-foot section in the lock, or the 1,000-foot section. They look as if they made rather a close fit in a 150-foot channel and very close to the bottom.

Senator KITTREDGE. They were taken that way, were they not? They were taken in the right position to show that, were they not?

Mr. STEARNS. They are a correct drawing as far as the width of the ship is concerned, and the depth and the width of the canal is concerned; and they show one ship in a canal——

Senator HOPKINS. That is under the sea-level plan, is it?

Mr. STEARNS. Yes; and also two other sections under the lock-canal plan, where the depth is 45 feet. You will see in those two wider sections that they show more water underneath and more water at the sides; and it certainly looks as if it would be more comfortable, especially if a ship were coming in the opposite direction. And it

should be remembered that even those ships are not as large as can be passed through these locks proposed by the minority.

There is one matter that occurs to me, in view of the statement that this canal is wider than the Suez Canal—that is, that the sea-level canal is wider than the Suez Canal.

The Suez Canal, as I understand, has a bottom width of from 108 to 118 feet. The ships that go through it—I picked out the four largest that were mentioned by Mr. Quellenec in giving us some statement as to the largest ships that went through the canal. They have there a length of 560 feet by 62 by 26, 500 by 71 by 26, 400 by 76 by 26, and 390 by 75 by 26. While there is one, a battle ship, which is very wide in proportion to its length—that is, 400 feet long and 76 feet wide—I do not think that they offered the difficulty to navigation that would be offered by a very long ship, and it is proposed to allow, say, a 93-foot ship to go through this canal, even in the minority plan, as against the widest one there of 76. But if that 93-foot ship should also be long, it seems to me it would be much more difficult to navigate in a canal, because if a boat occupying the large part of the section gets started a little to one side the water which is rushing back past the ship to prevent a vacuum behind it tends to crowd it over to one side.

Senator KITTREDGE. Mr. Stearns, may I return to this picture a minute?

Mr. STEARNS. Certainly.

Senator KITTREDGE. What is the draft of these boats?

Mr. STEARNS. It was originally given in a statement made to us by the Isthmian Canal Commission as 36 feet in salt water. I have seen a more recent statement as 38 feet. That is drawn as if it were 38 feet.

Senator KITTREDGE. What boat is this?

Mr. STEARNS. One of the two unnamed Cunarders that have not yet been launched.

Senator KITTREDGE. And what is their length?

Mr. STEARNS. About 800 feet. It is stated here as 788 feet.

Senator KITTREDGE. You say the draft is how much?

Mr. STEARNS. Thirty-six.

Senator KITTREDGE. That leaves them 4 feet of water?

Mr. STEARNS. If the canal has the full depth; yes.

Senator KITTREDGE. That is all there is to these pictures, is it not?

Senator TALIAFERRO. You have not a picture of one of the Cunarders in a lock?

Senator KNOX. Well, that is all the pictures purport to show, is it not? I do not understand that the pictures are intended to convey any other idea, are they, Mr. Stearns? These photographs are not intended to convey any idea to us except to show the relative size of the ships in the water in the lock and in the sea-level canals?

Mr. STEARNS. It was thought that a graphic representation would be an easy way and a satisfactory way to judge of the relative size of the ship and the section of the canal.

Senator TALIAFERRO. As a practical argument in favor of the lock canal?

Mr. STEARNS. I should think so—in favor of wide channels.

Senator TALIAFERRO. And deep draft?

Mr. STEARNS. And plenty of room under the boat. They steer badly, so I am told.

It is stated in the report of the majority (as having, I think, some bearing upon the question of canals) that all of the canals of the world, with one exception, were being widened; and then it added, "As this is going to press we learn that the other one is being widened, too." The tendency is very strongly in favor of wide channels, although ships get through narrow ones; and I believe myself that the wide channels and the deep channels have an immense advantage in navigation as regards safety.

Senator, your attention has been called to the question as to how often ships go aground in the Suez Canal. The only statistics available were some that were gathered in 1899 or 1900, at the time of the original Isthmian Canal Commission; and I would like to read those statistics to you, if they have not been called to your attention.

Senator KITTREDGE. Are they in the report?

Mr. STEARNS. They are in the report.

Senator KITTREDGE. If you will call our attention to the pages, that will be sufficient so far as I am concerned.

Mr. STEARNS. If that is all that is desired, the statement may be found on page 93.

Senator HOPKINS. If it is short, I would like to have it in connection with your testimony.

Mr. STEARNS. It is. These statistics were taken from the records of the Suez Canal and show the delays to traffic from ships grounding during a period of eight months, from January to August, 1899, inclusive. No delay of less than six hours was included. The groundings of more than six hours were 15 in number, the aggregate delays to the grounded ships being two hundred and ninety-two hours and twenty-nine minutes. In 14 of the 15 cases the channel was blocked so that other ships could not pass, the total time during which the canal was blocked being one hundred and eighty-five hours and forty-six minutes.

There are also, on this same page and in an appendix, statements of the blockades that have occurred in the channels in connection with the St. Marys Canal and St. Clair River. In one case the blockade continued for five days; 332 vessels were delayed, and the loss to navigation amounted to a large sum, estimated to be \$600,000. That is an estimate which, I understand, was made long ago and in connection with this particular work.

Senator TALIAFERRO. Does the report deal at all with delays occasioned in the lake plan?

Mr. STEARNS. It does, in great detail, as to the time of passage through locks. Mr. Noble has worked that out.

Senator TALIAFERRO. I mean delays by accidents. Do you know of any accidents that have occurred in the locks of any of the existing canals?

Mr. STEARNS. Yes. No ship has ever been injured in fifty years at the St. Marys Falls Canal. When I say "injured," I mean seriously injured. There have been little portions of a ship broken by coming in contact with gates or something, but no ship has been seriously injured.

The danger of accidents in a lock are not to the ship, because it moves there very slowly and practically the same as it would in

coming up to a wharf—even under better conditions, because the pier to which it comes is parallel with the line of navigation. Almost all wharves have only narrow ends, and there are currents near them.

Senator TALIAFERRO. I was speaking of the canal, Mr. Stearns, not the ship.

Mr. STEARNS. Oh, yes.

Senator TALIAFERRO. Do you know of any accidents that have occurred in the locks of any existing canals?

Mr. STEARNS. Yes; not of my own personal knowledge, but I have acquired this information.

Senator TALIAFERRO. I mean in the same way that you have acquired the information about the groundings in the Suez Canal?

Mr. STEARNS. Yes. There were three times when ships coming through the Manchester Ship Canal have gotten the wrong signals, or the signals have been wrongly understood, and they have turned their propellers and gone ahead instead of backing, with the result that the lock gates have been torn away, I think, on three occasions.

Senator KITTREDGE. Within what period?

Mr. STEARNS. Within the period of its existence. I do not know the dates. I think these have all occurred with ships that were going downstream, and it is the policy to close the gates behind them after they get into the locks—the upper gates. They were in the process of closing those gates and the ship went through the gates below and the upper gates came to with a bang. The ship did not get injured, I believe, in any case. It was either two or three times that that happened.

General DAVIS. Three times, I think.

Mr. STEARNS. There were three accidents in all. The ship did not get injured in either case there, and in both cases the upper gates swung together in such a way that they held and prevented the lock from becoming a mill race with the water rushing through it.

Senator DRYDEN. That was on the Manchester Canal?

Mr. STEARNS. Yes. There has never been an accident that has disabled the canal further than to put those locks out of commission; and that is provided against in the canal at Panama by the duplicate locks.

Senator DRYDEN. And no accident of that kind has occurred in any other canal that you know of?

Mr. STEARNS. There have been three somewhat similar accidents at the St. Marys Falls Canal. I do not remember those as well. One was in the case of a ship coming up from below, and it struck the lower gates, which had water against them, and pushed them open a little ways; then the force of the water reacted, and sent the ship back as if it had been an arrow from a bow, I believe.

Senator KNOX. What would happen, Mr. Stearns, if a ship were coming through this flight of locks, and she were to run through the gate of the upper lock?

Mr. STEARNS. The provision is made so that the vessels shall not run through.

Senator KNOX. By that safety gate?

Mr. STEARNS. By the safety gate.

Senator KNOX. Well, if that did not work?

Mr. STEARNS. But if you assume that the vessel went through both (which would not happen) there would nothing happen, provided the upper gates had been closed in due season after the ship went into the lock, if they closed up very quickly behind it, except to demolish the gates; and I think the ship might get into trouble.

Senator KNOX. That situation was described here by some witness as a possibility. He thought very serious damage would be done to the locks—almost irreparable damage.

Mr. STEARNS. I think that the precautions that are taken by those double gates—they must be very heavy gates in a canal of that sort—would be sufficient. But if they were not, the minority has provided \$2,000,000 in its estimate for putting up what are known as movable dams, and thirteen different plans for movable dams had been studied on the Soo Canal, and there was no question as to the feasibility of designing them; but within three months we could not do everything.

Senator KNOX. No.

Mr. STEARNS. So that that was put in as a sum of money, without providing the design. But those movable dams would be so arranged that they could be closed, and if a current should get started they would be closed immediately. It would not be possible, probably, to close those upper gates; the rush of water would make them come to with such a bang that they would probably be destroyed.

Senator HOPKINS. As I understand you, it is a very remote contingency that there would ever be accidents in the locks?

Mr. STEARNS. It has never happened with any canal in the world, with only single gates, so as to cause disaster. It breaks the gates; but with these double-gate precautions and all the provisions that can be made in management to take care of the matter, I do not believe there is the slightest danger.

Senator HOPKINS. As I understood you to say, for fifty years at the Soo, up here, they never have had even an accident of that kind?

Mr. STEARNS. Not to the ship; but they have had accidents that have broken the locks.

Senator HOPKINS. Yes.

The CHAIRMAN. Mr. Stearns, are you getting pretty well along with your statement?

Mr. STEARNS. I have very little more to say. There are one or two things that might be of interest.

The CHAIRMAN. We would like to have you go right along with them, then.

Mr. STEARNS. One I forgot to state, in connection with the maintenance of the canal. A ship going through a canal causes waves to flow out to the side, which wash against the sides; and if they are left in earth they would wash that earth down into the bottom of the canal. That is an additional cost in maintenance of the sea-level canal, because there would be the whole distance between the shore lines where that washing action would take place, and those waves are quite considerable if boats go with any reasonable degree of speed. Of course it would not occur in the sections which have rock sides; only where there are earth sides.

In the lock canal the greater part of this is lake navigation, where the waves would go away off to the shores, a long distance from the canal; and consequently they would not wash the material into the

canal. It is quite an important item in the cost of maintaining the canal.

The amount of earth canal on the sea-level section is, I think, between 21 and 22 miles. I do not know the exact figures; that is about it. On the lock canal the only sections in earth are $2\frac{1}{2}$ miles down to Limon Bay, and those are 500 feet wide, where the material, if it did wash from the edges, would not wash as much, it being farther from the ships which pass; and also, it would probably be deposited out toward the edges, leaving the middle to the larger depth.

No sum was included in either estimate for riprapping or paving the sides of the canal so that that washing would not occur except to a moderate extent. It would be quite a large item on the sea-level canal and a very small item if it were done on the lock canal; but I do not think it will be necessary on the lock canal, in view of the very great depth of channel.

Considerable has been said in the testimony with regard to leaving the tidal lock open. I do not think that is a feasible thing; and I quote practically what was said by one of the foreign members, who had had experience in that line. I think it was at a canal, the Kiel Canal, where there is not nearly the rise and fall of the tide that there is on the Panama side. I am not sure as to the rise and fall of the tide there, however.

General DAVIS. It is small.

Mr. STEARNS. It is small. But even under those conditions he said that they left the gates of their tidal locks open for a time, and they got a petition or a request from the shipowners that they should close those gates and let them lock through; it was too dangerous going through with the water rushing through. It seemed to be conclusive, in his mind, that tidal locks ought to be kept closed. And that was under conditions which are much more favorable to keeping them open than at Panama. If they should be kept open at Panama, with a rise and fall of the tide of, say, 6 feet above and below mean tide in ordinary neap tides, or with the lower tides, it would produce a very great rush of water through those locks and through the portion of the canal near the locks, which I should think would be dangerous. It would not only do that, but it would also diminish the depth of the canal at low tide, because the water would fall with the tide.

I think those are all of the single topics that I had to discuss. The question has been suggested as to what my view was as to the canal as a whole in the comparison of sea-level and lock canals.

The CHAIRMAN. I would like to have your opinion in regard to that. If you were going to own both canals, which one you would think the best, for the same money and the same time in its construction?

Mr. STEARNS. I have given that matter very careful consideration. It seems to me that a canal is a means of getting ships across the Isthmus; that it is a question of getting them across, in the first place and most important, safely, and, next in importance, to get them across quickly. In both of those respects I believe the lock canal is the best. It has within its depths and widths ample channels which will permit speed and safety, for while groundings occur in wide channels they occur much more frequently in narrow channels.

I believe that the lock canal has the greater capacity for traffic. When one imagines the traffic approaching 60,000,000 to 80,000,000 tons per year it will be realized that it would not be practicable to get them through if one ship had to be tied up for every other one that passed, there would be so many in the canal at one time. There would be a demand for widening the sea-level canal before any demand would come for the enlargement of the lock canal, except as individual ships might get to be so large as to require another set of locks, which would not be very costly.

Taking all those things into account, I believe that for the same time and money the lock canal is the better canal. I would give more for it.

Senator KNOX. There are locks on the sea-level canal as well, are there not?

Mr. STEARNS. One—or one pair.

Senator KNOX. One pair of locks?

Mr. STEARNS. Yes.

Senator KNOX. Where are they located?

Mr. STEARNS. Close to the Panama shore.

Senator KNOX. And do you know what the usable lengths of those locks are?

Mr. STEARNS. They are 1,000 feet long and 100 feet wide.

Senator TALIAFERRO. What is the lift?

Mr. STEARNS. The lift varies from nothing to about 10 feet.

Senator KNOX. Well, there is just the same chance of accident to gates and to ships in one of those locks as there would be in any other lock—in one of the sea-level locks?

Mr. STEARNS. There is the same accident danger to ships, but that is very small in any lock. There is the same danger of smashing a gate, but the result of smashing a gate would not be as serious as it would be in a summit-level lock.

Senator KNOX. Yes; I understand. That is all.

Mr. STEARNS. I might say in connection with that matter of the size of locks that if ships continue to increase in size, following the history of the past, that probably the difference in size between the locks that are 900 feet in usable length and those that are 1,000 feet in usable length would be reached in the difference in the time of construction of the canals.

That is, that if the lock-canal locks were outgrown in twenty years after the completion of the lock canal the sea-level canal locks would be outgrown in twenty years after the completion of the sea-level canal. That is, a difference of six years would account for a difference of 5 feet in width and a hundred feet in length.

The CHAIRMAN. Mr. Stearns, have you anything further to suggest to the committee?

Mr. STEARNS. No, sir; I think not.

The CHAIRMAN. I think, then, we will excuse you now; and we certainly appreciate your coming, and thank you very much for being here.

(The committee thereupon adjourned until Tuesday, March 20, 1906, at 10.30 o'clock a. m.)

STATEMENT OF JOHN F. WALLACE
BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.



ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Tuesday, March 20, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Ankeny, Morgan, Taliaferro, and Simmons.

FURTHER STATEMENT OF JOHN F. WALLACE, ESQ.

Senator KITTREDGE. Mr. Wallace, you testified before the committee some time ago regarding administrative matters.

Mr. WALLACE. Yes, sir.

Senator KITTREDGE. In that testimony you gave us the date when you first became connected with the canal as chief engineer.

Mr. WALLACE. Yes, sir.

Senator KITTREDGE. Do you remember what that date was?

Mr. WALLACE. That was June 1, 1904.

Senator KITTREDGE. And you continued as chief engineer until what date?

Mr. WALLACE. Until June 29, 1905.

Senator KITTREDGE. About the 1st of April, 1905, you became a member of the Canal Commission?

Mr. WALLACE. Yes, sir.

Senator KITTREDGE. And continued in that capacity until the same date in June?

Mr. WALLACE. The same date; yes, sir.

Senator KITTREDGE. So that in addition to your duties as chief engineer you were also a member of the Commission from about April 1, 1905, until June 29, 1905?

Mr. WALLACE. Yes, sir. After April 1, 1905, I was chief engineer, member of the executive committee, and Commissioner. About the 10th of April the Panama Railroad was put in my charge on the Isthmus as vice-president and general manager, but I was not able to assume charge of that road on the Isthmus until I returned there about the 25th of May, 1905.

Senator KITTREDGE. You have read the report of the Board of Consulting Engineers?

Mr. WALLACE. I have.

Senator KITTREDGE. And the views of the minority of that Board?

Mr. WALLACE. Yes, sir.

Senator KITTREDGE. Will you please advise us of the type of canal which, in your judgment, ought to be recommended by this committee to the Senate for construction?

Mr. WALLACE. Mr. Chairman, my single purpose in appearing before you at this time is to give you the very best judgment I have been able to form upon the two matters you are now considering and as to which I have, as you know, a very considerable knowledge. I need not repeat the experiences which I think justify me in speaking with some little authority upon the engineering problems before you, and I think I fully explained the somewhat exceptional practice I have had in dealing with large problems of construction similar in many respects to the problems confronting you in the matter of the Panama Canal.

I wish, therefore, simply as an American citizen, to put the judgment which I have formed on the basis of these experiences before you, and through you before the Congress, to assist in reaching what I am sure every member of it, of both parties, ardently desires to reach—a conclusion as to the best type of canal and the best method of doing the work involved in its construction. Of course I recognize that the committee may well differ from me and the majority of the Board of Consulting Engineers for the Panama Canal as to type of canal and may differ far more with far greater freedom as to the best method of constructing it, but I feel that I will have done my full duty when I have laid my views before you and given you, as far as I am able, the reasons upon which they rest in my own mind.

In considering the question of alternate plans for the canal, whether it should be upon a high level with locks, or upon a sea level without locks, my judgment as an engineer is controlled by several principles which commend themselves to me as really fundamental, and so far as I am concerned, conclusive.

In the first place it must be conceded that an approximately straight sea-level canal, of ample width and depth, is the best type of canal, and that any other plan which places restrictions upon the probable permanency of the canal itself, as well as upon the speed and the size and number of vessels passing through it, must necessarily render the canal far less valuable and far less desirable than if such doubt as to its permanency and such restrictions did not exist.

In the second place, it must be equally admitted that the only deterrent elements in accomplishing the more desirable result—that of the sea-level canal—are the two factors of relative time and cost, when this most desirable form is contrasted with the far less desirable form of a high-level canal with locks.

In the third place, it must be admitted that a very proper way to approach a discussion of the relative desirableness of these types would be to consider how much money the American people may be supposed to be willing to invest in the canal and how long they may be supposed to be willing to wait for its proper accomplishment.

After these important factors are determined the committee ought to be able to readily decide which of the two types of canal seems to it to be the better and to give its approval to the type it prefers.

Now, as to the cost. We have told the civilized world that the United States of America are willing to construct the Panama Canal for the benefit of the world and its commerce, including our own; and as we have voluntarily accepted this great duty, it is to be presumed that the people prefer that the Congress should approach it from a broad, general, and liberal standpoint, constructing the most permanent and best possible type of canal, rather than to offer to

the world an inferior type of doubtful permanency, especially as the best type of canal is one which, so far as can now be foreseen, will not have to be materially altered or enlarged and upon which our descendants may look with pride, with no occasion to regret any inefficiency or instability in the work due to our having been too careful of our money or too shortsighted in our engineering judgment.

The amount of tonnage which will pass through the canal when completed is, of course, largely a matter of conjecture, but it is certain that it will be large and ever increasing, and that considerable tonnage will be diverted from the Suez route. The phenomenal increase of tonnage passing year by year through the Suez Canal is a reasonable assurance that the continued prosperity and growth of the commerce of the world will justify the expenditure at Panama of the money required to give such commerce the best possible waterway between the two oceans. Judged by the capitalization and dividends now paid upon the stock of the Suez Canal it is apparent that the rates charged for transit through it are excessive, and on the assumption that the rates for passing through the Panama Canal will be considerably less, a very material saving will be offered to commerce if it takes the Panama route.

Assuming that the present amount of tonnage through the Suez Canal of, say, 10,000,000 tons per annum would pass through the Panama Canal, even at a dollar a ton, there would be an approximate income of \$10,000,000, which is sufficient to justify an expenditure of \$300,000,000. As the commerce passing through it will in the near future pay the interest upon the bonds issued to construct it, without taking into consideration any indirect commercial benefits which would accrue to this country, and without considering the advantages which would be derived from the canal in the improbable event of war, it would seem that an expenditure of \$300,000,000, a sum ample to construct the sea-level canal, would be abundantly justified, considering the probable rapid development of foreign and domestic trade and the indirect results to be derived from this great waterway. Under these conditions the increased expense of constructing a sea-level canal ought not to weigh very heavily in deciding the question of type.

Now, as to the additional time required for a sea-level canal, it may be predicted with some certainty that upon a basis of reasonable energy and the use of proper business methods of administration a sea-level canal can be fully completed in ten, or, to be entirely safe, say twelve years, and a lock canal, even if only 60 feet above sea level, will require seven, or, to be entirely safe, say nine years, on the same basis of energy and administration—a difference of only three years. I make this concession out of abundant caution; but considering that the work on the sea-level canal is plain, ordinary, everyday work of digging and hauling away what is dug, I do not believe very much additional time would be required for the sea-level canal. It does not seem, therefore, that the additional time required for the sea-level canal should seriously militate against deciding upon that type.

It must also be remembered that it is quite possible to secure even increased efficiency over that assumed to be now probable in case the work should be handled by a single contracting firm, unhampered by governmental methods and with every incentive to expedite and complete the work at the earliest possible moment. Indeed, under such

conditions it is very probable that the period suggested could be considerably reduced. Instead of one shift of ten hours the contractor might utilize electric lights and work two shifts.

If it is not too much to hope that the committee will decline to recommend any form of canal which is not capable of being in the future transformed into a sea-level canal without undue interference with the world's traffic and without undue additional cost, this fact alone should take the recommendations of the minority of the board of Consulting Engineers and the recommendations of the majority of the Isthmian Canal Commission out of really serious consideration; for it is difficult to see why any type of canal should now be authorized the destruction of any important feature of which, either by act of God or of man, would block all use of it until its restoration, particularly when such interruption of traffic would almost certainly extend over several years and the world having become accustomed to its advantages would incur such a loss of time with the greatest possible sense of injury.

There is another engineering problem which ought to have careful consideration, and that is whether the Congress will feel justified in indorsing the construction of any dam of large dimensions retaining a head of water of, say, 85 feet, the foundation of which does not extend to bed rock or to some equally impermeable and reliable strata. The engineering question may be thus stated: Is it either safe or wise to authorize the building of a dam $1\frac{1}{2}$ miles long to retain a head of water of 85 feet across an alluvial valley similar to the valley of the Chagres at Gatun, in which exist already two subsurface gorges, one of which alone is 1,000 feet across and 240 feet deep, which has evidently been refilled with a heterogeneous mass of gravel, sand, sandy clay, driftwood, and the general character of detritus brought down into the valley by the mountain streams?

With this situation in view it is greatly to be feared that the dam at Gatun, which is proposed by a minority of the Board of Consulting Engineers and which is indorsed by a majority of the Isthmian Canal Commission, might after some years be found incapable of holding back so great a head of water and withstanding the strain upon it. This apprehension is greatly emphasized by the character of the borings in this locality, because they have not been sufficient to determine the accuracy of the cross section which has been submitted as one of the exhibits of the Board of Consulting Engineers to the Isthmian Canal Commission. Sand or gravel may even underlie the indurated clay into which borings have only been made a short distance. The same remarks apply, though in a lesser degree, to the series of dams and barrages holding back a head of 55 feet of water which it is proposed by the minority report to construct across the alluvial valley of the Rio Grande on the Pacific side of the canal.

From an engineering standpoint it is difficult to understand why a much better place for the construction of a dam to control and regulate the floods of the Chagres River is not at Gamboa where it is positively known that the primary rock foundation exists at no greater depth than sea level, and where it is possible to construct a masonry dam founded on solid rock at such a moderate depth and in accordance with established methods, that its integrity will no longer give rise to question.

If, therefore, it is decided to disregard the recommendations of the majority of the Board of Consulting Engineers, and to build a lock canal, then it is to be earnestly hoped only such form of lock canal will be authorized as will be admissible in connection with the construction of a dam at Gamboa rather than at Gatun.

While for certain purposes and under certain conditions earthen dams of large dimensions carefully formed are permissible, in this case it is not believed that such form of construction should be seriously considered when it is possible to secure a masonry structure founded on bed rock; particularly when the work under consideration must be supposed to possess permanency, and is being erected as a monument to the engineering skill of our modern civilization. There is no urgency that to my mind would justify the great risk of earth dams at Gatun or La Boca.

The next important matter to consider and decide is whether the canal shall be constructed under the present method of management or whether a contract for the work shall be made with a single contracting firm. In the latter case the specifications, of course, should be of the most broad and general nature, leaving all detail engineering plans to the engineers of the contractor in order that he may have the fullest latitude in immediately meeting and overcoming such local difficulties as from time to time are sure to arise.

After the contract is let, there would, of course, be no reason for retaining a cumbersome governmental organization in reference to the work, for there is no doubt that the Corps of Engineers of the United States Army could most efficiently supervise the contractor engaged upon the work. All the governmental functions, including policing and sanitation, could easily be performed under the control and direction of the governor of the Canal Zone. It can not be doubted that these two methods, if adopted, will give entirely satisfactory results.

The question will naturally arise in doing the work by contract whether there are any engineering organizations competent to enter into such a contract and to construct a work of this magnitude, and such a question must be answered in the affirmative. Several well-known organizations are quite capable and competent to handle a work of this character, and there is no good reason why they could not be induced to make bids for it, if the Congress in its wisdom decides such a method of management of this great work is preferable to that which has existed for the last two years.

In considering the question of additional time required for the construction of a sea-level canal the prompt and efficient utilization of the Panama Railroad is a matter of very great importance; for if the railroad is provided without unnecessary delay, with the very best modern facilities and equipment, including double tracks with abundance of sidings, shops, wharves, docks, and warehouses, and especially with the latest and most approved appliances for transferring cargoes from ships to cars and from cars to ships, very many of the advantages the world's commerce would derive from the completion of the canal will be at once afforded to it. Indeed, in many cases of goods shipped from American ports destined to the west coast of South America, it will probably be found advantageous for them to go in a single ship to Colon and being transferred by the railroad to Panama, be reshipped in smaller vessels plying from that port to the different ports to which different parts of the cargo may be consigned.

There are two suggestions which since they were first made have been subjected to very careful and thoughtful review because of criticisms which have been passed upon them. The first is that the railroad should be substituted for the canal while the canal is in process of construction. If so, it should be completely separated in management and control from any steamship line at either end, as the canal itself will be, and the charge for transfer from ship to ship should be a flat rate per ton regardless of classification except that light and bulky articles should be rated at a certain number of cubic feet to the ton. This rate should not be in excess of \$2 per ton, even with the present limited amount of business and as the business increases the rate should be reduced as the receipts justify.

Of course railroad managers who are accustomed to through bills of lading and through rates naturally desire that the railroad should be considered only a link in the shipments from one part of the world to another and that the same cumbersome classifications should prevail to which they have been accustomed in the movement of transcontinental traffic; but all such intermeddling with the transit across the Isthmus will disappear as if by magic the day the canal is opened, and there is therefore not the slightest reason why it should not disappear now, and the world's commerce be proffered substantially the same advantages of transit across the Isthmus that under precisely the same circumstances it will enjoy when the canal itself is placed in operation. Under such a system of administration there is no occasion whatever for the Panama Railroad maintaining a corporate existence with offices in New York, for the road can be far better controlled by a single competent railway manager on the Isthmus who would, of course, be under the direction and control of the general contractor in case the entire work is let under one contract.

This arrangement alone would save a large annual expenditure now apparently wasted on the Panama Railroad organization and do away with the complexities which that organization evidently produces, while at the same time the embarrassing questions arising from the alliance of steamship lines with the transit across the Isthmus could be separately considered on their merits, leaving the Government at liberty to retain a line of transports for its own use or rely upon the boats reaching the Isthmus both from the east and the west, as the Government's best interest might dictate; but, however, Government transports ought not to have the slightest possible advantage over any competing line of ships.

The method thus suggested of operating the railroad as a simple transfer line across the Isthmus and therefore as an immediate and practicable substitute for the canal with a low flat rate or charge, common to all the world's commerce, is a practicable and simple proposition which the committee will readily understand even if it declines to approve it. Above all, it would remove at once all cause for charges of favoritism for or discrimination against any particular interest or section of our country or even between ourselves and foreign nations, and thus enable the United States to redeem immediately the promise it has given that the great waterway which it is now constructing shall offer equal advantages to all the world and special privileges to none.

It must also be remembered that with such an excellent substitute for the canal while the canal is being constructed, any slight delay

in construction will be of far less importance than if the present organization of the railroad in New York is maintained and its mystifying relations with through bills of lading and through rates continued.

The expenditures which will be necessary to put the railroad in condition for this important work have already been partly made and will be required in any event for the road to furnish the proper facilities for the construction of the canal, so that no considerable additional expense is involved in the proposition.

As the primary reason for the construction of the canal has always been given as that of affording free and unobstructed facilities for all commerce across the Isthmus, it would really seem to be our imperative duty to provide these facilities at the earliest possible moment, when it can be done at a very moderate cost and in a simple manner.

It is, of course, a fundamental practice in railroad maintenance and operation that all physical changes and improvements of railroad properties should be so conducted as not to interfere with or delay the current traffic, and the same principle should apply to the construction of the canal. The railroad should be used as an instrumentality for this construction, but it should not be so used as to be injurious to the present facilities for commerce. On the contrary, it should be enlarged, improved, and amplified for increasing such facilities in the manner already indicated.

If the committee should think that undue importance is being attached to this question, it may be suggested that when such a large measure of benefit to the world's commerce can be secured by the expenditure of so small a sum and in so short a time and so great a percentage of benefit to be ultimately derived from the construction of the canal be at once secured, the importance of intelligent and immediate action by Congress can readily be understood and is earnestly urged upon it.

It must be remembered, and it is well known to persons engaged in large transportation problems, that it is much easier to retain and regulate the movement of traffic along lines to which it has been accustomed than it is to regain it after it has been once diverted to new routes, and the committee ought not to overlook the competition of the Tehuantepec route, which is now being provided with every kind of facility for handling traffic from ship to cars and from cars to ship across that Isthmus, and which it is suggested ought to be immediately provided at Panama, so that not only the commerce now passing across the Isthmus at Panama may be retained, but every possible inducement offered to the constantly increasing commerce of the world to avail itself of the facilities of this route rather than allow itself to be diverted to the Tehuantepec route on account of lack of facilities at Panama.

In conclusion, it must be admitted that the problems now confronting the Congress are of a very embarrassing character, but the intelligence and patriotism of its members will surely enable it to reach satisfactory conclusions. When such conclusions are reached both as to type of canal, whether at sea level or with locks, and as to the best method of constructing it, whether under the present organization or by letting the contract to outside parties under the supervision of the Corps of Engineers of the United States Army, it can not be doubted

that its decision will meet the expectations of the people in all respects and satisfy the just pride that their country has undertaken the task of conferring upon the world the benefits of this great enterprise.

Senator KITTREDGE. When you arrived at the Isthmus about the 1st of June, 1904, you found engineering parties there that had been operating on the work?

Mr. WALLACE. Yes, sir. The line from Colon to Gamboa was covered with engineering parties; and they were first charged with a verification of the French topographical maps, and second, with making borings.

Senator KITTREDGE. Where were the borings made?

Mr. WALLACE. There was one party at Colon, under Mr. List; a second at Gatun, under Mr. Nichols; a third at Bohio, under Mr. Dauchy, and a fourth at Gamboa, under Mr. Ely. These several parties were again subdivided into smaller parties.

Senator KITTREDGE. Please tell us the result of the explorations and borings at Gatun especially, and also at Bohio.

Mr. WALLACE. In order to explain that situation I will state that when I first took charge I understood that the type of the canal had been practically established by the Spooner Act, although some deviation might be permitted from it; and I had read a paper by Mr. Ward, published in the transactions of the American Society of Civil Engineers, which has been made part of your record, and I was very much taken with the idea of a dam at Gatun. The first idea I had, after I had spent a week or so on the Isthmus and looked the situation over generally, was that that was the proper locality for a dam, if a lock canal was constructed, provided suitable foundations could be secured for it.

Senator KITTREDGE. Why was that?

Mr. WALLACE. In figuring out the various elements of cost, it gave a lock canal with the proper depths and widths for less money than the estimates made under the Spooner plan. That was the principal reason.

After we had made a very few borings at Gatun, however, we struck one of the gorges that are shown on the cross section that appears in this exhibit before the committee and found this loose, permeable stratification extending down to about 179 or 180 feet below the sea level, containing sand and freely water bearing. That convinced me that there was no hope of finding any suitable foundations for a dam inside of any reasonable distance, so I put my parties temporarily on other parts of the work.

Senator KITTREDGE. I wish you would explain in detail just what was done in making borings at Gatun and what was developed. You may use maps if you wish.

Mr. WALLACE. I do not see your cross sections here. I do not remember how many borings were made, but we made quite a number. [After examining maps.] I am not able to tell from this particular plan what part of these borings were taken under my jurisdiction.

The CHAIRMAN. I think all the borings are noted on this plan. I think one of the engineers a few days ago stated that fact.

Senator KITTREDGE. Some were made after Mr. Wallace left.

The CHAIRMAN. I think a number were made after you left, Mr. Wallace.

Mr. WALLACE. The railroad is on this side of the gorge [indicating]—that is, this cross section is a cross section across the valley, looking north, and some of the first borings that were made went down in this gorge about 179 or 180 feet. We made others that only went down a part of that distance, but as soon as I discovered that there was a gorge there and that that depth was below the possibility of finding a foundation with which a permanent contact could be made, or to which the foundation of a dam could be taken, I temporarily abandoned those borings and went to work with the same party and tried to find the character of the material through here, with the idea of making a cut-off in order to shorten the canal. That was afterwards abandoned, however.

After the Commission came down in August they were not satisfied in regard to my theory of the continuity of this gorge, so then we went to work and kept at it continuously from that time and took these other borings which you see here in order to determine, if it was possible, that we could find some place where the indurated clay was not so deep as it was at the point first selected for examination.

In other words, to present the matter more clearly to you, the principle I was working on was this: That in a work of this magnitude it would not be safe to construct any dam to hold back the head of water that would be necessary at that point unless we could go to bed rock with our foundations. That we had decided on as a fundamental principle. When we found that the gorge existed there, I could see no use of further explorations.

Senator SIMMONS. Do you mean, Mr. Wallace, that it is necessary that the whole dam should rest upon a rock foundation?

Mr. WALLACE. No; not necessarily; but that you should be able at least to carry a curtain—

Senator SIMMONS. I mean for the safety of the dam. Do you mean that it is necessary that the whole of the dam should rest upon a rock foundation?

Mr. WALLACE. No; not the whole foundation. But it is necessary—that is, in my own opinion—that you should carry down a contact, or what we call a curtain wall, to the bed rock or to some impervious material.

Senator SIMMONS. The whole length of the dam?

Mr. WALLACE. The whole entire length of the dam.

Senator KITTREDGE. Why is that?

Mr. WALLACE. That is, from one side of the valley to the other. Why, it is so as to cut off the percolation of any water underneath your structure.

Senator SIMMONS. Is that what you call a core? What do you call that construction which you say must go down to the rock?

Mr. WALLACE. If it is an earth dam which you are building on a rock foundation you put in what we call a puddle core. That is, you put in a core in the center of that dam that is impervious to water.

Senator SIMMONS. Yes.

Mr. WALLACE. If you desired to build a large earth dam in an alluvial valley you would want to carry that core down to the bed rock or to some impervious material. We generally call it a curtain wall.

The CHAIRMAN. What you mean by the curtain is the wall made of concrete or stone, or whatever it may be, that comes next to the water, and then you fill it behind with earth? Is that it?

Mr. WALLACE. No; I mean a subterranean construction, a subsurface construction that will go clear to the bed rock.

Senator SIMMONS. What is that to be made of—masonry or timber?

Mr. WALLACE. That can be of timber if it is entirely submerged, or it can be of concrete, or it can be of any material, of whatever nature, that will be permanent and that will, without any question, shut off the percolation or flow of water underneath your dam.

Senator TALIAFERRO. That is, this curtain has no part whatever in the foundation except to prevent an underflow of water?

Mr. WALLACE. That is it, exactly. Now, there are two things to be guarded against—

Senator SIMMONS. This curtain goes down to the rock and extends the full length of the dam?

Mr. WALLACE. Yes. To make it clear to you, perhaps I can explain it a little differently.

The foundation for a dam has to perform two functions. One is to support the structure upon which it rests; the other is to prevent the water from running through underneath it.

Senator TALIAFERRO. And undermining it?

Mr. WALLACE. Either undermining it or else exhausting your reservoir of its water supply. You may have a flow of water underneath a dam that may drain the dam area and still may not ruin your structure as a dam. Have I made that clear to you?

Senator TALIAFERRO. Well, Mr. Wallace, if there was sufficient underflow to drain that dam, would it not in all probability impair the structure itself?

Mr. WALLACE. Possibly, but not necessarily so—that is, it might be possible to drain that water off absolutely and not be able to hold water in your dam and still not destroy the dam. But I would not take the chances on it if I were building the dam, though I can not say that it would not be possible to do it.

Senator SIMMONS. Is it proposed to construct any such curtain as you now speak of at Gamboa?

Mr. WALLACE. At Gamboa? No, sir; because at Gamboa the foundations themselves go to the bed rock. At Gamboa the primary rock foundation comes up—not the indurated clay, where you do not know what is underneath it, but the actual basaltic rock, of which the backbone of the continent itself is made. The deepest part at Gamboa is only at sea level. You only have to go 45 or 50 feet below the bed of the Chagres River to put the foundations of your dam right down on the bed rock, which is the backbone of the continent, and there is not any question at all about its integrity.

Senator SIMMONS. But after you get to bed rock at Gamboa you propose to construct an earth dam there with a masonry core, do you not?

Mr. WALLACE. No; not necessarily so. That was a detail that was left for subsequent determination.

Senator SIMMONS. Has anybody suggested anything there except an earth dam with a masonry core?

Mr. WALLACE. Yes, sir; I understand that the majority of the advisory board suggested a masonry dam, and a masonry dam is the thing, it seems to me, to construct there. The only reason that anyone ever suggested an earthen dam with a masonry core at Gamboa was from the fact that there was so much material to dispose out of Culebra that the material could be wasted at the site of that dam, and it would afford a place to put that material. As far as an engineering proposition is concerned, the proper thing to build there is a masonry dam.

The strength of a masonry dam founded on the bed rock is a matter of absolute mathematical determination. There is no guesswork about it. You can logically reason from the integrity of one masonry dam to another masonry dam, because you have elements there that are what we call determinate. But you can not so figure on an earthen dam. An earthen dam is absolutely a question of judgment and opinion. You can build an earthen dam in Massachusetts or New York or Colorado that will stand a head of 85 feet of water, and it is no criterion at all that the same dam at Gatun or in South Africa or at any other place would stand it, because the conditions are never the same. I mean the conditions under the surface. That is a matter of what you may call engineering judgment if you are in favor of an earth dam, and you may call it engineering guesswork if you are not.

Senator TALIAFERRO. Mr. Wallace, is not this earthen dam which is proposed by the minority at Gatun a dam of unusual strength?

Mr. WALLACE. Yes; it is; but as I said awhile ago, the unusual size that you make that dam may affect its integrity as a dam if there is no water flowing under it and if it is on a proper foundation. But there are two gorges that are underneath it. The deeper you go in those gorges the more water-bearing the material is. You find the same mass of loose gravel in the bottom of this gorge here that we found in the bottom of the gorge at Bohio, a really water-bearing stratification, practically a subterranean river. Now, when you add to that a pressure of some 38 pounds to the square inch, due to this 85 feet of head of water which is behind this dam bearing on this water to press it through that stratification, no engineer can tell you what is going to happen there.

Senator SIMMONS. Mr. Wallace, I want to see if I understand you. If I understand you, your position is that you can not guarantee the safety and integrity of an earth dam unless it is either built upon a rock foundation or unless there is a curtain going down from the surface, through the subsurface, to a rock foundation?

Mr. WALLACE. Yes, sir.

Senator SIMMONS. That is your position?

Mr. WALLACE. That is my position.

Senator SIMMONS. And that curtain must extend the full length of the dam?

Mr. WALLACE. The full length of the dam; yes, sir.

Senator SIMMONS. That is, not only across those gorges—down where those gorges are—but down where this indurated clay is?

Mr. WALLACE. It must go into that. If this indurated clay is all indurated clay, if you get a good foothold into this clay it is a proper foundation.

Senator TALIAFERRO. I want to ask you a question before you get away from that.

Mr. WALLACE. May I finish this matter—just a minute?

Senator TALIAFERRO. Yes, sir.

Mr. WALLACE. But no man can tell what is here. While it is possible and while it is probable that that indurated clay does extend to the bed rock, you have not any surety of it.

Senator SIMMONS. What I want to get from you is your opinion as to whether that curtain has to go down through that indurated clay until you get to bed rock, in order to guarantee the integrity of your dam.

Mr. WALLACE. No, sir; not if that indurated clay does go to bed rock; but I would find that out first, before I built a dam that this great work was dependent upon.

Senator SIMMONS. It must be demonstrated that the indurated clay goes to the bottom, or you must go through the indurated clay with your curtain down to the bed rock?

Mr. WALLACE. Yes, sir.

Senator TALIAFERRO. Now, Mr. Wallace, your answer to Senator Simmons seems to lay down the general proposition that an earth dam is not safe unless the foundations go to bed rock, or there is this curtain going to bed rock, for the purpose of cutting off an underflow of water.

Mr. WALLACE. Yes—that is, of course, unless the material may be of an impervious nature.

Senator TALIAFERRO. You did not put that qualification in your answer before. I was going to ask you if there were not a great many earth dams in this country which have been proved to be safe?

Mr. WALLACE. Yes; but if you had a thousand earth dams in this country that were proven to be safe, they would be no criterion that one at Gatun would, unless the conditions at Gatun coincided with the conditions of these that had been proved here.

Senator TALIAFERRO. Exactly so; but it would answer your general proposition that earth dams were unsafe?

Mr. WALLACE. Oh, no; I did not say that; I beg your pardon.

Senator TALIAFERRO. Well, that earth dams were not safe?

Mr. WALLACE. What I say is this, that I, of my own judgment, would not construct an earthen dam in an important work like this or with a great head of water behind it unless it was either founded on the rock or founded on some impervious material like indurated clay or unless it was protected by a curtain that was taken to the bed rock or to the indurated clay or to a surface through which the water would not flow.

Senator TALIAFERRO. I thought you meant that.

Mr. WALLACE. That is what I meant; yes.

Senator SIMMONS. What did you call these two formations here?

Mr. WALLACE. Down in the bottom here there is loose gravel.

Senator SIMMONS. But what did you call that [indicating]? We have been calling it a gulch.

Mr. WALLACE. I called it a geological gorge.

Senator SIMMONS. A gorge; yes. Now, Mr. Wallace, eliminating those two gorges altogether, supposing that they were not there, but that the formation where those gorges are was the same as this here [indicating]—in other words, that it was all indurated clay clear

across the line of this canal and that that indurated clay extended down 200 feet, the full length of the canal, do you give it as your opinion that you could not construct upon the surface of that indurated clay an earthen dam which would be absolutely safe?

Mr. WALLACE. No; I do not say that, because, as I said before, it would depend entirely on what was underneath it here.

Senator SIMMONS. I am asking you a hypothetical case.

Mr. WALLACE. Well, you have to take——

Senator SIMMONS. I can not get at your views unless you will allow me to ask you a hypothetical case.

Mr. WALLACE. I know, but engineers do not decide things on hypothetical cases. We decide the form of our structure on what we find underneath.

Senator SIMMONS. But it might be of some benefit to us to have your opinion on a hypothetical case. Of course I do not want it unless you are willing to give it.

Mr. WALLACE. Well, engineers are a good deal like some judges; they do not give their opinions on hypothetical cases.

Senator SIMMONS. I will ask you the question, and you can answer it or not, as you see fit. Eliminating the two gorges there, supposing that the material in those gorges was the same as that on either side of it, and that you have, therefore, for the full length of the dam, a foundation of indurated clay extending 200 feet below the surface, I ask you the question if, with those conditions, an earth dam there would not be practically secure and safe?

Mr. WALLACE. I would not put an earth dam in there in an important work of this character under the conditions you name unless I knew what was under that 200 feet of indurated clay, and unless I knew how far above and below the dam the indurated clay extended.

Senator SIMMONS. That is an answer to the question.

Mr. WALLACE. Yes, sir.

Senator ANKENY. Mr. Wallace, that indurated clay is never of uniform thickness, is it?

Mr. WALLACE. That is the reason, or that is one of the reasons, why I would not trust an important structure of that kind on it unless I knew what was underneath it.

I have had some experience with this kind of clay. I put in a bridge across the Missouri River quite a number of years ago for the Santa Fe Railroad Company. When I first took charge of that structure they had a line of borings across the valley. That line of borings struck an indurated clay that was a great deal heavier and harder than this indurated clay is; and the engineer that was sent to take those borings had reported that he had found a foundation substantial enough to construct the piers of that bridge on; and the bridge was planned with its caissons and its piers and everything to go to that depth.

When I arrived on the ground I commenced to examine the character of some of the rock borings and this clay, and I was not satisfied that he had gotten into a permanent stratification. So we went on through, and after going through some feet of this material we struck gravel and sand, and so forth, below. We found indurated clay in there that weighed 120 pounds to the cubic foot, and that was more of rock nature, really, than this indurated clay is here; and underneath it we found a mass of loose material, gravel and so on,

that we had to carry the piers of that bridge down through. Instead of going, as we expected, about 20 feet, we had to go 65 or 75 to 80 feet below the surface of the water, depending on stage of water.

Senator MORGAN. What place are you speaking of now?

Mr. WALLACE. I am speaking of a bridge foundation that I put at one time across the Missouri River at Sibley.

There is a section of country that Senator Kittredge is familiar with—in the Dakota country—I think up near the Jim River district, where the Missouri River comes down along the mountain slope of the continent at a much higher elevation than a large part of Dakota. In South Dakota you can put down almost anywhere a pipe of almost any size and get a flowing artesian well from it. I think the Senator will bear me out in that, at least to a degree.

Senator KITTREDGE. That is right.

Mr. WALLACE. That water evidently comes underneath from the Missouri River, and it flows through this sand and gravel and a fine silt—the silt is much finer than the material we found in this gorge here—and under several hundred feet of indurated clay. Am I correct in that?

Senator KITTREDGE. That is absolutely right.

Mr. WALLACE. And so much water flows through that stratification that there are times when there is more water in the Missouri River at Yankton than there is at Sioux City. Is not that correct, Senator?

Senator KITTREDGE. That is true.

Senator DRYDEN. Mr. Wallace, do the engineers who have examined the subject all concur with you in your opinion?

Mr. WALLACE. I do not know; I have not conferred with any of them.

Senator DRYDEN. You have not read their testimony?

Mr. WALLACE. I have read their testimony; yes, sir.

Senator DRYDEN. Have you observed in your readings whether they do or do not agree with you?

Mr. WALLACE. Some of them do and some of them do not—or, rather, to put it the other way, I agree with some of them and with some of them I do not agree.

Senator DRYDEN. It comes to the same result?

Mr. WALLACE. It comes to the same result; yes, sir.

Senator DRYDEN. There are a number of very eminent engineers who hold that that dam can be safely built across those gorges.

Mr. WALLACE. I presume there are; but I am simply speaking for myself.

Senator DRYDEN. Precisely.

Mr. WALLACE. And for myself, I would not do it.

Senator DRYDEN. Will you point out to me, if you please, while we are on this subject, on the map which shows the dam, just where the dam will cross these gorges?

Mr. WALLACE. I am not familiar with these maps; but one of the gorges in the map is here, and the other one is here—that is, this hill, in which they evidently have designed the sluice gates—the spillway—is in between these two gorges.

Senator DRYDEN. About what is the length of the mouth of those gorges—the top of the gorges?

Mr. WALLACE. That one is about 1,800 or 2,000 feet across, and this one is about—a little over a thousand—about a thousand.

Senator DRYDEN. Yes; thank you. I did not quite get your point when you said that certain conditions might make a dam safe in Massachusetts but would not apply on the Isthmus.

Mr. WALLACE. Yes, sir.

Senator DRYDEN. I did not quite get that point.

Mr. WALLACE. What I meant by that was that there is no similarity in respect to the foundations.

Senator DRYDEN. Yes.

Mr. WALLACE. As far as the constructing of the dam itself is concerned, after your foundations are secure, if you construct a dam with reasonable care, with the same kind of material, and see that the layers are all properly put in, you can construct your dam itself as well in one place as you can in another. But what I meant to say was that because an earth dam had a proper foundation or was on a material that was not permeable by water in Massachusetts, it is no sign, if you construct a dam on the Isthmus, that you would find the same conditions occurring underneath the surface. You understand what I mean?

Senator DRYDEN. Yes.

Mr. WALLACE. There are two elements in the earth dam proposition. One is the structure which we intend to make, the elements of which can be determined. The other is that part of the structure which nature has made and which is not the same in one locality as it is in another. You might not find in the whole wide world another condition exactly similar to this.

That is the point I was trying to make—that the conditions underneath the dam in Massachusetts were no criterion as to what the conditions would be underneath the dam at Gatun, unless they were found to be identical.

Senator DRYDEN. The depth of this dam is about a half a mile, as I understand, from the head to the end of it?

Mr. WALLACE. Well, yes. Here it is, underneath here, on this lower map.

Senator DRYDEN. I think it has been testified that it is about a half a mile.

Mr. WALLACE. Yes, sir.

Senator DRYDEN. Is not the fact of that enormous depth, which I understand to be entirely unprecedented, far beyond anything that has ever been constructed before, a very important factor as furnishing a resisting force for the seepage of this water?

Mr. WALLACE. No, sir.

Senator DRYDEN. You hold it would make no difference whether that dam is of such a depth as that or smaller?

Mr. WALLACE. Except this: Except so far as it would make a longer area between where the water might reach this substratification and where the water might come from, and increase the friction due to the flow of water through the material. If that material compressed this gravel down in here it would be another proposition. But experience has shown us—at least my experience has shown me—that the weight of that dam on top of this material would have no effect whatever on the flow of water through this gorge below here.

It may compress some of the upper stratifications in which there is vegetation or alluvial matter.

Senator MORGAN. By "the gorge below here" you mean the deepest gorge?

Mr. WALLACE. Yes; the two deep gorges; the two gorges at Gatun.

Senator MORGAN. And this is the deepest one?

Mr. WALLACE. Yes. The same thing would apply to the other one.

Senator MORGAN. Yes; I merely want to get the record right.

Mr. WALLACE. The compression would take place in the upper stratifications that are made up of vegetable matter or of alluvial matter, and the effect of those compressions will be an inequality in the settlement of your dam, and the probabilities of cracks and breaks in it in line with the edges of these gorges. But the pressure of that dam will have no effect whatever as to the flow of water through this water-bearing stratification in the bottom of the gorges.

Senator DRYDEN. Would not the fine matter which washes down in the silt fill up the little, infinitesimal crevices in this alluvial matter, so as to constantly make it more water-tight?

Mr. WALLACE. Under some conditions it might; under other conditions, no.

That, in fact, is such an insignificant proposition that it is not strong enough to be an element upon which to base a decision of this kind. It has not done it so far. You find the deeper you go here the coarser this material is and the more water runs through it.

If a dam is built here, the possibilities are, you will find, that silt may never come in against the exact dam itself. It might not for ages; it might not for hundreds of years, because it will come in from the side creeks and will be deposited wherever the water is still, and there will be very little that may come down against this dam in the water that is against it, because the water will be still for quite a distance above it. You might, where that material would settle on sand of a certain character. If it did settle, it would have a tendency to make it more impermeable than it was before. But I do not think we could trust in this dam on checking off that flow of water by that means at all. I think the risk would be too great.

Senator DRYDEN. Does the great extent of this dammed-up water add anything to the weight or to the influence of this head of water seeking an outlet through this seepage?

Mr. WALLACE. The weight of the water is due to its head and not to its volume, except this, that over the entire bottom of this dam there is a downward pressure of, say, 38 or 40 pounds per square inch. That pressure is also horizontal, applied to this water flowing through the dam. That pressure exists over all this entire area, so that if half a mile away from here there was another vein of gravel underneath the indurated clay, and the inlet to that might be a mile above your dam or 2 miles, that weight would be there transmitted on that water to push it through under that clay, and you might find springs develop and waterways develop below your dam a great ways off even from these gorges, if there was any continuous strata that was water bearing that was connected with any of this water above the dam and any of this area in the swamps below. Springs might come up miles away from it, due to that cause, because that pressure is underneath the entire surface of your dam, no mat-

ter how many miles it may be in extent, due to the height of the water above the point upon which the water rests.

Senator DRYDEN. If it should be necessary in building across these gorges to make a provision such as you have referred to—running down these aprons until you strike a strong, sufficient foundation—is that impracticable from an engineering standpoint?

Mr. WALLACE. Well, in this particular case I would not undertake to do it—that is, if it was a work that I was doing for clients. No engineer would like to say that anything in an engineering way is impracticable. It is possible to close that off by a great many means, but you can not get at it to see it, and a great deal of it would have to be left to the discretion and judgment of the men that did it on the ground; and whether it could be done or not, or how long it would take or how effective it would be, are very uncertain quantities.

Senator ANKENY. I infer from that that the weight of that dam would increase the percolation. Is that right?

Mr. WALLACE. No, sir; I do not mean to say that the weight of the dam will increase the percolation.

Senator ANKENY. The water above would increase it?

Mr. WALLACE. The water behind it, in the lake that would be created by the dam, would increase the percolation, due to the head of the water.

Senator ANKENY. That is what all this means?

Mr. WALLACE. Yes, sir; that is what all this means. What I meant to say, further, is that, in my judgment, it would be a very unsafe thing to predicate this important work on a structure built at that point.

Senator ANKENY. Upon a plan open to these objections?

Mr. WALLACE. Yes, sir.

Senator DRYDEN. Have you found any other weak point in that scheme for a dam except these two gorges?

Mr. WALLACE. I do not like the lock proposition that goes with it.

Senator SIMMONS. You said you made some borings after you went down there?

Mr. WALLACE. Yes, sir.

Senator SIMMONS. What was the greatest depth of your borings?

Mr. WALLACE. I think some of them were 200 feet. As I said before you came in the room, we abandoned the borings at one time, after we had commenced them and gotten down about 179 or 180 feet. Afterwards I went back again and explored that valley and made a great many other borings all through there.

Senator SIMMONS. Did you get through the indurated clay?

Mr. WALLACE. No, sir; I did not go down through that. All I tried to do was to develop these gorges, because when I found one depth that was below what I considered a practicable depth to take a foundation to that, to my mind, settled that locality.

Senator SIMMONS. Were your borings altogether in the gorges?

Mr. WALLACE. No, sir. They were all over; some of them down here [indicating on map].

Senator SIMMONS. How deep did you go in the gorges?

Mr. WALLACE. My recollection is that before I left the deepest I found was about 200 feet.

Senator SIMMONS. How deep did you go through the indurated clay?

Mr. WALLACE. Whenever we struck the indurated clay and went into it 10 or 15 feet we stopped.

Senator SIMMONS. You did not prosecute your borings to the extent of finding what was the character of the material below the strata of indurated clay?

Mr. WALLACE. No, sir; because, to my mind, that was entirely unnecessary. Having found that there were deep gorges there [indicating on map], it looked like a waste of money to undertake any further experiments there. If that location had been selected for a dam and I had been instructed to build a dam on that location, I would not have stopped until I had gone clear through and into the rock and gotten through several stratifications, so that I could have found the geological sequence of the various stratifications.

Senator SIMMONS. Your 200 feet borings down those gulches there did not reach strata of rock or other hard substance?

Mr. WALLACE. No, sir.

Senator SIMMONS. Why did you stop at 200 feet? Why did you not go deeper down?

Mr. WALLACE. The reason was this: We were crowded for men, and we were crowded for material, and we had other questions that were of great importance that we must solve, and we needed every man and every machine that we had. As I abandoned that in my mind as a place for a dam when I got down that 200 feet and did not find any suitable material for a foundation, it was, to my mind, simply a waste of time to continue.

Senator SIMMONS. When you got down 200 feet and did not find any solid substance you reached the conclusion satisfactory to yourself that that was not a proper place for a dam?

Mr. WALLACE. Yes, sir.

Senator SIMMONS. When was it that you reached that conclusion?

Mr. WALLACE. That was, I think, in August, 1904.

Senator SIMMONS. Since that time you have been opposing this proposition to put a dam there?

Mr. WALLACE. No, sir. I went back again, at the request of the old Commission, and we took additional borings, because their theory was that at some place else across that valley we might find a continuous ridge of this indurated clay upon which this dam might be built, and it was on that chance that we continued our investigation.

Senator SIMMONS. Did you make borings elsewhere in the valley with a view to ascertaining whether conditions were different there?

Mr. WALLACE. Yes. That is the reason all these black borings were taken from here away above the dam [indicating on map].

Senator MORGAN. Did you ever find that continuous ridge of impervious material?

Mr. WALLACE. No, sir; we did not.

While these borings were going on we had been boring at Bohio and had gotten down 167 feet at Bohio, in a gorge there. We had followed that gorge clear up to Gamboa, and we found it ran out at Gamboa and the rock came up to sea level. My natural supposition was that, going down to 200 feet here [indicating on map] and 167 feet at Bohio and finding that all the way up the valley the rock pitched and would be found at some very great depth here [indicating on map], but certainly under 250 or 300 feet at this point [indicating on map], that we certainly would not find that it was at a

higher elevation lower down the gorge than we found at Bohio, because the evidence all seems to show that this gorge had been formed by the flow of water, and that water must, of course, have been running downhill toward the sea.

Senator SIMMONS. It was in August, 1904, that you completed these borings in the gulch?

Mr. WALLACE. No, sir; it was August, 1904, that I found out that one of these gorges existed; but we took a great many additional borings after that.

Senator SIMMONS. When was it that you completed the borings as to those gorges and made up your mind that that site would not do?

Mr. WALLACE. That was in August, 1904.

Senator SIMMONS. That is what I understood you to say.

Mr. WALLACE. That was with this reservation, that if we did find—

Senator SIMMONS. I am talking about this site.

Mr. WALLACE. But I mean to say this: That we did not abandon that entirely, but it was with the reservation, of course, that if we did find a barrier of this indurated clay extending clear across the valley, and then found that that was down to the bed rock, and that there was no water-bearing strata under it, we might go back to that and put a dam there.

Senator SIMMONS. But you did find upon this identical situs these gorges and you did bore down 200 feet?

Mr. WALLACE. Yes, sir.

Senator SIMMONS. And you came to the conclusion, as a result of those borings, that this precise place would not do?

Mr. WALLACE. That is correct.

Senator SIMMONS. What I want to ask you is this: Is there any report of your to the Commission or any written statement of yours to the Commission, made at that time, of the conclusion you had reached in this regard?

Mr. WALLACE. Yes, sir; that is contained in letters addressed to Admiral Walker, the chairman of the Commission, and it was also covered by verbal reports that I made to the Commission when they were on the Isthmus in that month.

Senator SIMMONS. You wrote letters to the chairman of the Commission?

Mr. WALLACE. Yes, sir.

Senator SIMMONS. Giving your opinion as you have stated it to be here?

Mr. WALLACE. Yes, sir.

Senator SIMMONS. In August, or about August, 1904?

Mr. WALLACE. Yes, sir; 1904.

Senator SIMMONS. After that opinion was given by you did you make any more borings at this particular place or in the line of the dam at that particular place?

Mr. WALLACE. In the general vicinity. That matter was referred to Mr. Nichols, and we let him use his judgment as to where he should make his borings after that time. In other words, the consideration of the whole problem of physical research from Mindi clear up to Bohio was left in the hands of Mr. Nichols to investigate as he saw fit.

Senator SIMMONS. As a matter of fact, did Mr. Nichols continue his borings along the line of this Gatun dam?

Mr. WALLACE. In that general vicinity; yes.

Senator SIMMONS. I am not speaking of the general vicinity. Did he make them along the line of this Gatun dam?

Mr. WALLACE. I could not tell you from memory. At that time I used to get monthly borings that he made. It has been almost a year now since I have paid any attention to it, and the data is not in my hands, so that I could not answer your question definitely.

Senator SIMMONS. Is there anything in the reports or upon the maps that indicate whether any borings were afterwards made right along the site?

Mr. WALLACE. Yes, sir. Mr. Nichols made weekly and monthly reports of everything that he did, and the data as to exactly what he found and did are on file in the chief engineer's office, at Panama.

Senator SIMMONS. The data will show the exact location of the borings?

Mr. WALLACE. Yes, sir.

Senator TALIAFERRO. You do not identify the borings that were conducted under your direction?

Mr. WALLACE. No, sir; if I had my reports here I could. I have reports of these borings. This map is made to a different scale and the borings are differently numbered from what they were on my reports, and I could not identify the exact borings.

Senator MORGAN. Mr. Chairman, I ask that the chairman call for those reports, or copies of them.

Senator SIMMONS. Yes; we would like to have them.

The CHAIRMAN. Do I understand that they are here or at Panama, Mr. Wallace?

Mr. WALLACE. Those are at Panama. It may be possible that you will find them in a consolidated annual report. Just before I left the Isthmus I commenced to shape up my matters for an annual report. All the engineers under me received instructions as to how to prepare their matter and what matter I wanted. Mr. Nichols and these other engineers that had charge of borings had everything tabulated up to the 1st of July, 1905. It is barely possible that copies of that matter may be here in the office of the Commission. I think very likely they may be.

The CHAIRMAN. There may be copies here of this work that was done at Panama?

Mr. WALLACE. Yes, sir; there should be.

Senator TALIAFERRO. Could you not look over the annual report and ascertain whether this information was embraced in it?

Mr. WALLACE. Why, it would not be in the annual report. It would be in the reports of Mr. Dauchey, and Mr. List, and Mr. Maltby, and Mr. Ely, and Mr. Nichols, and these other assistant engineers. It would be in their reports to the chief engineer.

Senator MORGAN. Which you transmitted to the Commission?

Mr. WALLACE. No, sir; I did not get a chance to do that.

Senator SIMMONS. I would like to have inserted in the record the letters that Mr. Wallace referred to a few moments ago, which he says he wrote to the chairman of the Commission, giving it as his conclusion, as a result of his borings through these gorges there, that this place at Gatun, which has been selected by the minority as a

proper place for the construction of a dam, was not an available place.

Senator KITTREDGE. I think that is a proper request.

Senator MORGAN. I thought those letters had been called for on my suggestion.

Senator SIMMONS. You spoke of reports.

Senator MORGAN. I call them reports.

The CHAIRMAN. These letters will be here, Mr. Wallace?

Mr. WALLACE. They should be here.

The CHAIRMAN. The request for the letters will be made, Senator.

Senator TALIAFERRO. That was in the form of a report, was it?

Mr. WALLACE. No, sir; it was in the form of my regular letters right along.

The CHAIRMAN. Those letters would be along in the year 1904?

Mr. WALLACE. Yes, sir; addressed to the chairman of the Commission.

Senator SIMMONS. In August or September of that year.

Mr. WALLACE. My recollection is that you will find that matter also treated in a report that I made to the Commission under date of February 1, 1905. Along about in the winter the Commission sent down an engineering committee consisting of Professor Burr, Mr. Parsons, and General Davis, and they called upon me for a report on the Isthmus, so that I made them a short, condensed report, and I think it was on February 1, 1905; and in that report I described the work that had been done up to date, and gave the conclusions that I had arrived at up to that date. That is very short, and it wound things up to that period.

Senator MORGAN. Probably that would cover the whole matter.

Mr. WALLACE. That might cover what you want.

Senator SIMMONS. We would like to have that, and the other, too.

The CHAIRMAN. I assume that all borings, or copies of them, are in the office here?

Mr. WALLACE. They should be; yes.

On the Isthmus the borings, cores of all the material, were very carefully preserved, showing the number of the hole and the character of material at each foot below the surface all the way down, so that you could examine the actual material. That is the way we got our information about these things. I used to visit these assistant engineers and go through these samples. I would say, for instance, "What did you find down here in hole No. 1 at 50 feet, or at 125 feet below the surface?" And I would follow that stuff down and see it, and take it in my hands, and consequently I knew.

Senator SIMMONS. Did you find any water currents down in that gulch?

Mr. WALLACE. Yes, sir.

Senator SIMMONS. How deep were those?

Mr. WALLACE. The deeper down we went the more freely the water seemed to flow, although there were occasional thin layers of clay.

Senator SIMMONS. What was the depth of the first current you found?

Mr. WALLACE. I do not remember.

Senator TALIAFERRO. It is on that blueprint there.

Mr. WALLACE. I do not like to speak from this blueprint, because I do not know whether this was made from my borings or from subse-

quent ones. The general conclusion is all that concerns you, I suppose, and the effect that it had on my views was that it was not such a location for the dam—

Senator SIMMONS. But every fact about this concerns us, in making up our opinion. We are glad to have your suggestions, but we have to form an opinion about it ourselves, and every fact about it is material.

Mr. WALLACE. Then I would go down there, if I were you, and look at the samples of those borings.

Senator MORGAN. Did you have a paper similar to that blueprint, or some other drawing showing the borings made by you and reported by you to the Commission?

Mr. WALLACE. Yes, sir; it came in on the monthly reports. They were sections. For instance, if they took these particular borings in a month [indicating on profile], or those there [indicating], they would send sections like that; but not a completed section like this blueprint.

Senator MORGAN. Your borings are in charge of the Commission?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And that map, or those maps?

Mr. WALLACE. Yes, sir.

Senator MORGAN. We want those, Mr. Chairman.

Senator KITTREDGE. Is it possible, Mr. Wallace, to secure a rock foundation in the gorges you have described?

Mr. WALLACE. I do not think so.

Senator KITTREDGE. The depth is too great?

Mr. WALLACE. Yes, sir; the depth is too great.

Senator KITTREDGE. Is it possible to put in a curtain wall of the character you have mentioned, in such manner as that you can certainly say that all the water will be cut off?

Mr. WALLACE. Well, that word "possible" makes it a hard question to answer, Senator.

Senator KITTREDGE. Is it probable?

Mr. WALLACE. It is possible, but I would not consider it reasonably practicable. To put it in a little different way, if it was the only location that there was anywhere for a dam, and we could not build the Panama Canal unless we put the dam at that particular point, I should first try, if I had anything to do with the work, or in the way of advising any engineer that had anything to do with it, to attempt to shut these gorges off in some way. It would be a very expensive, tedious proposition, but it might be possible to do it. I would not like to say that it would be impossible. I would say, most positively, that I would not attempt it for a moment if there was any other locality where I could build a dam where I would not have these difficulties, and which would still enable me to build the Panama Canal.

Senator MORGAN. You would not recommend it to a client as a safe operation for investment?

Mr. WALLACE. I certainly would not.

Senator KITTREDGE. Is it beyond tried experience?

Mr. WALLACE. It is beyond anything that has been done in an engineering way.

Senator MORGAN. I want to get a better idea than I have of the topography of this country between Bohio and the site of the Gatun

dam, as put down on the report of the minority. What is about the distance between the borings at Gatun that you made down to 157 feet and—how many feet was it?

Mr. WALLACE. To a maximum depth of 200 feet while I was there.

Senator MORGAN. At Bohio?

Mr. WALLACE. Oh; at Bohio? One hundred and sixty-seven feet.

Senator MORGAN. State the distance from that line to Gatun, just in miles, if you please.

Mr. WALLACE. It is practically about 10 miles.

Senator MORGAN. At Bohio you bored across and developed a deep gulch?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And you got to real rock, solid rock?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Not this indurated clay?

Mr. WALLACE. No, sir.

Senator MORGAN. And there you found boulders washed in?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And lodged in this gulch?

Mr. WALLACE. Yes, sir.

Senator MORGAN. In your borings between that and Gatun, did you develop the continuity or a prolongation of this gulch?

Mr. WALLACE. Not from Bohio down to Gatun; but we took borings from Gatun up the river some distance.

Senator MORGAN. I know that; but down below?

Mr. WALLACE. We did not go below Bohio, because there was no site between Bohio and Gatun where we considered the conditions—that is, the topography of the country above the surface—as suitable for a dam.

Senator MORGAN. This blueprint that you have been speaking from this morning indicates that there are two deep gulches there; one, the narrower one, is how many feet deep?

Mr. WALLACE. It is 250 feet deep.

Senator MORGAN. And the wider one is how deep?

Mr. WALLACE. About 200 feet.

Senator TALIAFERRO. That deep gulch is 258 feet deep, is it not?

Mr. WALLACE. I was just speaking approximately from what this map said. I was not pretending to give exact figures. It is shown here on this map as being 260 feet.

Senator MORGAN. Yes.

Mr. WALLACE. Yes. I had always understood that it was called 250 feet in depth. There is one boring that goes down 10 feet below, here [indicating on map].

Senator TALIAFERRO. The borings there, I understood, have gone down 258 feet.

Mr. WALLACE. I see one figure on here marked 260.

Senator MORGAN. I want to get you to state, if you please, whether the Chagres River in its present location runs over or above either of these borings.

Mr. WALLACE. Yes, sir; that is, in a way. There is a diversion channel over this deepest boring which was made by the French. The Chagres River is not over the deepest boring, but both the diversion and the river itself are inside of the limits of these gorges, only above them.

Senator MORGAN. Does the Chagres River separate into two channels there, so as to make an island between?

Mr. WALLACE. In connection with this diversion channel it does. The French made a diversion there that I presume followed the lines of what formerly had been a river. I think there is no doubt but what at some ancient period there were two channels, one in each of these beds.

Senator MORGAN. And there was an island that appeared on the topographic surface?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And through one of those channels the French dug a diversion channel?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Have you any information as to the purpose for which they dug that channel?

Mr. WALLACE. Well, that was to keep the side water that came in from flowing into the canal. The general theory of diversion channels was this: That on each side of the canal itself channels would be cut from one depression to another, or one part of the river bed to another, so that it would intercept the streams that came down on the hills on each side, carrying that water out to sea, to keep it from running into the canal proper.

Senator MORGAN. And the diversion that you speak of was a part of that scheme for keeping the water out of the canal?

Mr. WALLACE. Yes, sir.

Senator MORGAN. In the borings, as indicated on this blueprint, the augers were put down through that diversion and also through the main channel of the river?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And this insular mass was between the two?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And that insular mass was composed of indurated clay?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And the gulches between had washed out and been filled up with débris from some more elevated place?

Mr. WALLACE. Yes, sir.

Senator MORGAN. The insulated mass—I mean the general body of the material lying from 40 to 50 feet beneath the surface—was this indurated clay?

Mr. WALLACE. Yes. I mean this indurated clay was on the sides, but there was no continuity across these gorges of indurated clay.

Senator MORGAN. I understand. I suppose—of course it is a supposition with you and everybody else—that that indurated clay had been deposited there in some far distant period of the past and that those gorges had washed out?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And had left an island between the two, which is demarked on the surface to-day by these two branches of the Chagres River which run around it?

Mr. WALLACE. That is the natural supposition.

Senator MORGAN. Did they ever, in the borings that they made as shown on this blueprint, reach solid rock beneath this indurated clay?

Mr. WALLACE. No, sir.

Senator MORGAN. At the deepest of those borings, or at some of them, did they reach through the indurated clay and into a softer mass of material?

Mr. WALLACE. No. The borings only went down into the indurated clay far enough to be sure they were in that material. In some of those places there were other kinds of clay on top of the indurated clay, and in order to determine that the clay was indurated clay the borings went some distance into it in some places; but there was no attempt ever made to go through it.

Senator MORGAN. There is nothing below the indurated clay of softer material?

Mr. WALLACE. The borings did not go far enough to show what there was below the indurated clay.

Senator MORGAN. Not even in that deepest part?

Mr. WALLACE. No, sir.

Senator MORGAN. At the lowest depth of that deepest fissure there into which borings were made you still found the indurated clay?

Mr. WALLACE. Yes, sir.

Senator MORGAN. This blueprint shows that tubes were driven down, like the tubes of an artesian well, for the purpose of determining whether water would flow through them as the borings descended; and it was found that at this heavy line which is here, which I believe indicates sea level or just below that, and at the same elevation almost in each of these borings the water poured out of the tubes. Would that indicate that that water was at a level between those points where it poured out of the tubes, and that that level was maintained either through this indurated clay in this insular place or went around it?

Mr. WALLACE. It would indicate that that water was connected with other water at a higher elevation, and that it was freely flowing through the material that the water came through.

Senator MORGAN. That was taken, I suppose, as satisfactory evidence that in some way the mass of water that was flowing out of the tubes in each of these gorges was a continuous body?

Mr. WALLACE. Yes, sir; and a continuous stream, and that the material in the part of the gorge to which that tube ran was what we call freely water-bearing.

Senator MORGAN. Have you any idea, or have you any reason to suppose or to believe that the water which rose at equal heights in these tubes in these respective deep gorges ran through the body of indurated clay or ran around it?

Mr. WALLACE. From the data that has been presented I would judge that the water followed these gorges, and, if the clay was indurated, that the water was confined to the gorges.

Senator MORGAN. That it was confined to the gorges and ran around this insular place that had been washed out on both sides?

Mr. WALLACE. Yes, sir.

Senator MORGAN. In building the dam upon the top of that material, say, 30 or 40 feet below the surface of the earth, to span each of these gorges, that dam would rest upon material more or less permeable and more or less soft, including wood or other stuff. In order to make that dam secure, would it be necessary to shut out or close

out permanently this conduit that supplied water from a common source and that ran either through or around this insular position?

Mr. WALLACE. Yes; it would be necessary to cut it off.

Senator MORGAN. By what means could that be cut off? By what known engineering means could it be cut off?

Mr. WALLACE. That same question practically was asked me a while ago, Senator, only not in that particular form, and I said then that it might be possible to cut it off, but I would not undertake to do it if I was an engineer of that work if I could find any place else to build my dam.

Senator MORGAN. Is there any certain known engineering formula or proceeding or process by which that water could be cut off other than by taking out the material down to and below it and starting the foundations of your dam below the point where this water flowed?

Mr. WALLACE. The way you have suggested would be the most thorough way to do it; but I have never known it to be done at such great depths as that.

Senator MORGAN. Very good.

Mr. WALLACE. About 100 to 110 feet below the surface of the water is about the maximum depth to which you can go down and clean off material and build up and about it. Of course there are processes by which you could drive sheet piling at some greater distance, or inject cement, or use the freezing process, and all that sort of business; but the depths of that, the success and utility of it, would be, to say the least, doubtful.

Senator MORGAN. If I understand the project of the minority of the consulting board of engineers, they propose first of all, in constructing this dam, to go down and take off the softer material that lies on the surface of the earth until they get down to about the general level of the indurated clay; then they propose the construction of an earth dam upon that basis to span both of these gorges. Is that a correct assumption?

Mr. WALLACE. That is the way I understand it.

Senator MORGAN. A dam constructed in that way, and leaving the material as it is in these two deep gorges, would rest upon a body of earth or body of material through which and below which there is now an actual flow of water. I want to know if a dam constructed in that way and at the levels that I have been describing can be made to stop that flow of water; can it be done otherwise than merely through the pressure of the weight of the superstructure of the dam upon the underlying material?

Mr. WALLACE. In my opinion the weight of the superstructure of the dam would not shut it off.

Senator MORGAN. It would not?

Mr. WALLACE. No, sir.

Senator MORGAN. Is there any other way to do it, except through the weight of the superstructure?

Mr. WALLACE. In that form of construction, no; and, as outlined in their plan, no.

Senator MORGAN. That is the plan that is recommended for the dam?

Mr. WALLACE. As I understand it; yes, sir.

Senator MORGAN. If the superstructure of the dam, the earth part that is filled in and superimposed upon this foundation there that I

have been trying to describe, by its weight and pressure closes up ultimately this water flow, would that not be done at the expense of irregular settling in the dam?

Mr. WALLACE. Yes; but it would not close up the water flow.

Senator MORGAN. I know you think it would not. I am assuming the possibility that it should do it.

Mr. WALLACE. It is rather a hard presumption.

Senator MORGAN. Would it not be done at the expense of, I will say, the integrity of the dam above, so that it would sink?

Mr. WALLACE. Yes; but, Senator, in my view, you will have two things that will happen there.

Senator MORGAN. What are they?

Mr. WALLACE. The first thing is negative, and that is, that in my experience I have never yet seen weight that is superimposed on water-bearing stratification of gravel that was fully saturated ever have any tendency to shut off the water, because you can not compress it. There are voids there, and the gravel and the sand and the stone make arches.

Senator MORGAN. The water itself is incompressible?

Mr. WALLACE. And the water itself is incompressible, of course. Near the surface where you have any vegetable deposits you will have settlement, and you will have compression. But those are not the strata through which the water flows, but those are the ones that will compress, and the result will be a tendency for that dam to crack on lines perpendicular with the edges of these gorges.

Senator MORGAN. To have fissures?

Mr. WALLACE. Yes, sir; and those fissures will have a tendency to let the water through them, and will have a tendency toward weakening the structure.

Senator MORGAN. If a fissure should form in this dam, perpendicular, I will say, to either of these gorges, or between their borders, between their walls, would not such a fissure as that endanger the sweeping out of the entire structure from end to end when the water was at a height of 80 or 85 feet?

Mr. WALLACE. It would have a tendency to make a break in the dam where these fissures occur.

Senator MORGAN. When a fissure occurs under a head of 80 or 85 feet of water—

Mr. WALLACE. It is generally disastrous.

Senator MORGAN. Disastrous?

Mr. WALLACE. Yes.

Senator MORGAN. Can it be otherwise?

Mr. WALLACE. Of course I would not like to say that that thing would actually occur at that point.

Senator MORGAN. No; we do not any of us attempt to say what will occur in the future.

Mr. WALLACE. But I would not take the chances on it.

Senator MORGAN. That, then, is one of your material objections to the construction of this dam, if I understand you?

Mr. WALLACE. Yes.

Senator TALLAFERRO. You favor the sea-level canal, I see by your article?

Mr. WALLACE. Yes, sir.

Senator TALIAFERRO. Do you favor the plan as laid down by the Board of Consulting Engineers?

Mr. WALLACE. Well, in general—that is, as far as the main canal is concerned, its alignment, and its general size, etc. The only two points in their report that I would be disposed to question—not to criticise, but to question until I could give it more deliberate consideration than I have been able to with the other duties that I have had to perform—has been whether or not it would be advisable to go through between Ancon and Sosa on the Panama side and construct that new channel or simply to enlarge the present canal channel up La Boca way.

Also, I am not thoroughly satisfied from the examination I have made of it as to whether these longitudinal breakwaters are better than it would be to put this breakwater across here, according to the old plan. I have my doubts about that. But that is a detail, compared to some of these other questions, of course.

Senator KITTREDGE. Is the change of the channel at the La Boca end a matter of detail as compared with the other matters?

Mr. WALLACE. Yes, sir; the present channel is around this way [indicating on map]. Of course this makes a straighter shoot out to sea, and so is a little better, that is true; but there is a great deal of rock through here [indicating], and evidently one idea of their coming down here was to get the tidal lock in here [indicating], instead of up here at Miraflores where it was originally planned.

The CHAIRMAN. What do you think of the width of the sea-level canal for business for the future?

Mr. WALLACE. It is so much larger than anything that exists, than the Suez or any other maritime canal of the world to-day, that it seems to me that it would be ample for the start. Up to San Pablo, and possibly to Obispo, it would cost comparatively little to give you an extra 100 feet in width, if you ever wanted it, in these earth sections.

Senator TALIAFERRO. How about the Pacific side as to extra width?

Mr. WALLACE. Up to San Pablo I would say, in round numbers, that you could get an additional 100 feet in width for not to exceed \$10,000,000, if you wanted it. That is on the sea-level proposition.

The CHAIRMAN. From that to the Caribbean Sea?

Mr. WALLACE. Yes, sir. And it would be possible to widen the section with moderate expense from there up to Obispo. But this section, of course, from Obispo through to Pedro Miguel, would be common to all your various plans, no matter what their height, on account of the heights of the ridges. From Miraflores down to the sea, two or three million dollars ought to give you your additional 100 feet. There are some lumps of basalt that come up in here [indicating on map] where you might have to make some rock excavation under water, but I do not think they are material. So that you would have very little difficulty in getting any width that you wanted up to Miraflores.

Senator TALIAFERRO. From Panama Bay to Miraflores, what do you estimate that it would cost for a width of 500 feet?

Mr. WALLACE. I could not tell you unless I went into the figures and examined them carefully. It would not be prohibitive at all. It would be very moderate.

Senator TALIAFERRO. With a 500-foot canal from the Pacific to Miraflores, would it be necessary to use the tidal lock?

Mr. WALLACE. No, sir.

Senator MORGAN. You say it would not?

Mr. WALLACE. No, sir. The channel now is very narrow up here to La Boca. This channel you see here [indicating on map], although it is out in the bay, is practically in the canal, and there is no trouble at all in navigating this at all stages of the tide up to here [indicating].

Senator MORGAN. I want to ask about that for just a moment. If I understand you correctly, now, a sea-level canal 500 feet wide and 40 feet deep of prism would dispense entirely with the necessity for a sea-gate, if that was extended, you say, to Miraflores?

Mr. WALLACE. Yes, sir.

Senator MORGAN. There would be no occasion for a sea-gate at all?

Mr. WALLACE. No, sir; there would be no occasion for a sea-gate between that point and Miraflores. Of course, if you have a narrow channel through Culebra, the probabilities are that you would have to have a sea-gate in there at some place; but no engineer, Senator, has ever yet been able to make any calculation to determine what the velocity of the currents would be due to an open canal without any tidal locks. They can not answer that question. I can not, I will admit it.

Senator MORGAN. That depends upon fluctuations of the winds and all that on the ocean?

Mr. WALLACE. The uncertain element is this: It depends on the relative size of the different sections of the canal in regard to each other. As a rule, what creates a high tide is a funnel-shaped entrance of a bay. That is, the ordinary tides come into it, and then being confined, pressing up, and rising, and making a curve of that nature [illustrating], of course, over a very long distance. That is what makes the extraordinary tides in the Bay of Fundy. And it is the general shape of Panama Bay that creates the high tides there at Panama. The effect of tide on the canal would depend a good deal on the sequence of the shapes of your channel. And if you had a long channel of absolutely uniform width the effect of that tide would be very soon dissipated on account of the friction of the water on the sides of the canal.

Senator TALIAFERRO. So that if you had a sea-level canal of 400 or 500 feet width from ocean to ocean there would be no necessity—

Mr. WALLACE. There would be no necessity for any tidal locks at all.

Senator MORGAN. It would take an ocean of money to build it, though.

Mr. WALLACE. If you had a canal of any width so that two ships could freely pass each other—I mean under a speed of 4 or 5 miles an hour—you would not have any necessity for any tidal locks.

The CHAIRMAN. Do you think large ships, the largest ships that are being built now and that are already built, could pass at a speed of 4 or 5 miles an hour in a waterway 150 feet wide?

Mr. WALLACE. Not both of them. The ordinary practice would be to tie one of them up.

The CHAIRMAN. One of them would be tied up?

Mr. WALLACE. That would be the ordinary practice, to tie one up to a bank and let the other pass it.

The CHAIRMAN. With the changes which you suggested in the plan a few minutes ago, having the canal widened from this end down to the sea, and from the other end also, what would be the length of the narrower part?

Mr. WALLACE. That would be 8 or 10 miles.

The CHAIRMAN. About 10 miles?

Mr. WALLACE. Yes, sir.

The CHAIRMAN. It would be 150 feet wide there?

Mr. WALLACE. No, sir; that would be built 200 feet wide. They propose to make that 200 feet wide at the summit level, as I understand it.

The CHAIRMAN. I thought it was 150 feet.

Mr. WALLACE. I may be mistaken.

Senator MORGAN. It is 200 feet.

Mr. WALLACE. Where they propose to make their canal 150 feet wide, I understand, is where they are in the mud, and where they have to have a flat slope, say, a slope of two to one, which means this: That a bank of the canal, if it is 40 feet deep, would be 80 feet out from the perpendicular on one side and 80 feet on the other, so that your canal between bank and bank would be 310 feet wide at the surface of the water. So that only vessels of the deepest draft would have to confine themselves to the center 150 feet of width.

Senator MORGAN. There are no vessels that draw 40 feet of water?

Mr. WALLACE. I do not think there are any that draw that now. I think 30 feet to 33 feet are about the heaviest drafts.

The CHAIRMAN. It is reported that they are building a couple of vessels that will draw 38 feet, I believe.

Mr. WALLACE. It would be a rare thing that you would ever have two of these great ships that would happen to pass in this narrow place—perhaps once in a year. If you have a large vessel and a small one passing each other you have ample width, because the small vessel could pass the large one entirely outside of this 150-foot channel and still have plenty of water—your vessel of 25-foot draft, say.

Senator TALIAFERRO. Will you step over there to the map and illustrate from what point on the Pacific side you would suggest a greater width to the canal—up to what point from the bay and up to what point on the Pacific side?

Mr. WALLACE. As I have just been explaining, the majority of the Commission practically give that greater width now by the flatness of their slopes; but from the entrance of the canal on the Panama side to Miraflores you could get almost any ordinary width that you wanted—four or five hundred feet—at moderate expense.

Senator TALIAFERRO. Would you say \$10,000,000 would do it?

Mr. WALLACE. I should say \$10,000,000 would do it on the Pacific side.

Senator TALIAFERRO. Now, go to the Atlantic side.

Mr. WALLACE. On the Atlantic side it would take about \$10,000,000 for each additional 100 feet in width up to, say, about San Pablo. That is just simply my general judgment on what I know of the general locality and the average depths, etc.

Senator TALIAFERRO. You spoke in your pamphlet here of the canal costing \$300,000,000. Taking the canal recommended by the Board

of Consulting Engineers, would you say that that could be widened to 500 feet from either ocean up to these points that you have designated at a total cost not to exceed \$300,000,000?

Mr. WALLACE. I would say that it could, eliminating the \$50,000,000 which was paid for the canal itself and for the concession down there.

Senator TALIAFERRO. That is all eliminated in the report of the Board, is it not?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Your estimate was \$300,000,000 for the entire canal?

Mr. WALLACE. Just before you came in I undertook to make a suggestion showing that I thought we could afford to spend that much money for a canal that was satisfactory.

Senator MORGAN. A sea-level canal is what you meant?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And cutting it through the Culebra Heights, of course?

Mr. WALLACE. Yes, sir.

Senator TALIAFERRO. You meant to undertake to show that such a canal, built at a cost of \$300,000,000, would be a profitable investment?

Mr. WALLACE. Yes, sir; that is, eventually. It would not be right off, but in a broad way it would be. If the competition which the Panama Canal would bring on the Suez would cause a reduction of \$1 a ton on the freight—not on the tonnage measurement, the way they compute their tonnage, but on the actual goods themselves—through the Suez Canal, why, on their present tonnage there, it would yield over \$10,000,000 a year, which would be saved to the commerce of the world. It would not come to the United States in tolls, but would be saved to the world's commerce immediately.

Senator MORGAN. It does not occur to me that we are out for the purpose of making money for the world. When we get to digging canals in Mars, that may be. [Laughter.]

Mr. WALLACE. I thought we were, Senator. I thought our position before the civilized world was that we were digging this canal for the benefit of the world.

Senator MORGAN. Now, let me ask you two or three questions. In building a sea-level canal, you would necessarily retain the dam at Gamboa?

Mr. WALLACE. Yes, sir.

Senator MORGAN. As a regulating work?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And that would back up a great volume of water into lakes, according to the incoming of the waters from the affluents?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Would that dam at Gamboa supply a sufficiency of water for all commercial purposes for a lock canal between, say, Gamboa or Obispo and Miraflores or Pedro Miguel?

Mr. WALLACE. The dam at Gamboa would be practicable and usable for a lock canal of any height or level that you might want to have there, up to 90 feet, 60 feet, or any other height.

Senator MORGAN. Practically usable, you say?

Mr. WALLACE. Yes; it would also furnish you your water for the entire Zone, and it would furnish electric power to run the Panama Railroad and light the entire Isthmus from one side to the other.

Senator MORGAN. Then it would be quite sufficient for the eight or ten miles across the Culebra Cut if a lock canal should be constructed between Obispo and Miraflores?

Mr. WALLACE. It would be abundantly sufficient; yes, sir.

Senator DRYDEN. Mr. Wallace, you have spoken of a plan for a sea-level canal which is not recommended by the majority. If you were confined to the recommendation of the majority or the minority, which one of those plans would you recommend?

Mr. WALLACE. Why, the majority report, decidedly. I do not recommend a plan differing from the majority report. I simply said, Senator, that there were one or two points that I question. I was asked to criticise that, and I said that there are one or two points that were suggested by the majority report that I was not sure in my own mind whether those particular details were the best or not; but as far as the plan is concerned I would like to go on record as indorsing their general plan.

Senator DRYDEN. The plan of the majority?

Mr. WALLACE. Yes, sir.

Senator DRYDEN. Do you think that a sea-level canal as narrow as recommended by the majority is a safe canal for all big vessels to navigate?

Mr. WALLACE. Yes; I do.

Senator DRYDEN. Supposing an accident occurs to a big vessel, and it blocks the canal, and other vessels are in the canal coming both ways, what is going to happen if those vessels happen to get in there and find that canal blocked up in a way that may prevent traffic perhaps for weeks?

Mr. WALLACE. I do not grant that it would delay traffic for weeks, because it would only be a matter of a few days, possibly. Of course it depends on how efficient they are in getting it out. But it is just like it is on a railroad: We wreck a train in a tunnel or we wreck a train in a deep cut, and the first thing we do is to clear it out and restore traffic. We use dynamite or fire or anything that is necessary to remove the obstruction.

Senator DRYDEN. Is it so improbable that a vessel might meet with such an accident in there that it would become impossible to take it out without great expense of time and money?

Mr. WALLACE. I can not imagine anything that would happen to a vessel sinking in the canal prism—I mean in the channel itself—whether it is a lock canal or a sea-level canal, with the appliances with which a great work of that kind should be provided, and the men skilled to use them, that could prevent the removal of a wreck in a very short time.

Senator DRYDEN. There is a margin of but 2 feet in depth in this proposed canal for the biggest vessels now in course of construction. In the case of a vessel steaming through under its own head of steam, might it not strike bottom with a margin so small as that? Will there not be danger of that?

Mr. WALLACE. It depends on the velocity with which it is moving.

Senator DRYDEN. But it would not have to move at a very great velocity, would it, if it was extremely heavily loaded?

Mr. WALLACE. Well, that statement would apply to either a lock or a sea-level canal.

Senator DRYDEN. I think that is true; therefore I wanted your opinion on that as applicable to both plans.

Mr. WALLACE. I should think for a vessel with a draft of 30 feet that you would want more than 2 feet clearance. But there is this to be considered: I do not know of any harbor in the world to-day that will let a 38-foot draft steamship into it.

Senator MORGAN. What depth?

Mr. WALLACE. Thirty-eight feet.

Senator DRYDEN. Could not such a vessel get into New York Harbor?

Mr. WALLACE. No, sir.

Senator DRYDEN. How are these big Cunarders going to get in?

Mr. WALLACE. They do not come in drawing that much water. A vessel may have a possible draft of 38 or 40 feet, but that does not mean that it will be loaded to that draft. It may not be loaded to that draft once in the lifetime of the ship.

Senator DRYDEN. Of course; that I can understand perfectly well.

Mr. WALLACE. Take the situation at New Orleans. When I was with the Central we had a very heavy export business, and we were loading sometimes three, six, eight, ten, or twelve ocean steamers per day at our docks—the Stuyvesant docks there. We had vessels there that had a draft of 30 and 32 feet of water—15,000 to 18,000 ton ships; but they loaded for the bar at the jetties, over which there was 26 feet of water.

Senator DRYDEN. At no point in the sea-level canal, I take it, would a vessel be able to proceed except at a very moderate rate, even where the canal is 200 feet wide?

Mr. WALLACE. Take the case of the Suez Canal to-day; their depth is very moderate—I do not remember what it is, but it is less than 30 feet—and their widths are much less than at Panama, and yet the commerce of the world goes through there.

Senator DRYDEN. When you were speaking of the Gatun dam, Mr. Wallace, you started to say something about the locks—that you did not like the locks—but you were interrupted by another question, and diverted.

Mr. WALLACE. What I meant was this: I may be mistaken, but in my own examinations of those borings—there have only four or five borings been taken throughout the entire length of the site on which it is proposed to build those locks, and those locks with their approaches and wing walls extend upward of a mile in length; and my criticism on the lock plan was this: First, the continuity of the locks in flight, being so close together, so that if you had an accident in one it might affect the other; and second was the view that it is very difficult any where in clay, in any country, for a great distance, to secure a foundation that is absolutely of a uniform and homogeneous nature; and with the great weight that these locks will have it will be a very serious question, in my mind, whether or not, unless you had a perfectly homogeneous and uniform foundation under them, you would not run the danger of having your heavy, immense, massive masonry crack, due to unequal settlements. And it would seem the part of prudence, before a lock plan of that magnitude and importance is undertaken, that the most thorough borings should be made over that entire area, and at least as close together as 100 to 200 feet apart, both laterally and longitudinally.

Senator DRYDEN. These borings have not yet been made, then?

Mr. WALLACE. I understand that they have not. While the general surface of the ground may look the same, in that country you can not tell what you have got until you get down into it. And in case there should be softer material toward the edges of this hill, in which they intend to put this lock, under the surface, and that material should not be as dense as it was under the center of it, which is a very possible situation, something that you naturally find almost anywhere under similar conditions, you are liable to have more settlement on the ends than you would in the centers of your structure, and these locks, as I understand it, are to be in series, in flight—that is, practically connected together.

Senator DRYDEN. Leaving out this danger which you have just now spoken of, do you think that there is any other danger, as to these big vessels crushing these locks?

Mr. WALLACE. No ship ever moved in the world but what there was a liability of its running into something, if there was anything for it to run into, and if its movement was controlled by the human mind. That applies to a ship, it applies to a railroad train, and it applies to everything that moves, the movement of which is directed by the personal element; and if you run into them you are liable of course to crash from one lock down into the other. As long as a vessel or car or anything moves by machinery, and that machinery is controlled by the human mind, you are liable to have errors and you are liable to have accidents happen.

Senator DRYDEN. Can you testify as to the usable length of these locks? There has been some little difference, it has seemed to some of the committee, as to their usable length.

Mr. WALLACE. There seems to be some difference. In reading the testimony I notice that there is evidently a difference as to an appreciation of the facts in the plans. I have not been able to get at the exact drawings, to be able to speak intelligently on that point, but that is a matter that it seems that the Commission ought to be able to show definitely by their actual detailed plans, what the usable length of those locks would be. That they should be a thousand feet long and 100 feet wide, I do not believe would be questioned. I think that should be their minimum dimensions.

Senator ANKENY. Mr. Wallace, I would like to ask you what effect these large vessels in the sea-level canal would have upon those low banks that you speak of; what the effect of the "wash" would be, as we call it. Would it not wash material into the prism of your channel again?

Mr. WALLACE. No; not the way they propose to build them. They have very flat submerged slopes.

Senator ANKENY. You know there is a danger of that thing, do you not?

Mr. WALLACE. Yes, I know there is; but these vessels move at a very slow speed, and not like our Mississippi River steamboats on high water against the levee.

Senator ANKENY. I had that in mind.

Mr. WALLACE. I supposed that you had. The speed at which the vessel would move through the canal would not be enough to give rise to that danger.

Senator ANKENY. That would not be one of the dangers?

Mr. WALLACE. No, sir; that is, of course, something that is common to all forms of canals.

Senator ANKENY. I understand in comparison it is, but it would not forbid operating the sea-level canal?

Mr. WALLACE. No; not at all. What would happen there would be this: In these low sections this slope is very flat, so that the wash might change that slope a little, so that it might be one of the elements that might go to make up your cost of maintenance in a long series of years.

Senator ANKENY. In the way of continual dredging?

Mr. WALLACE. In the way of dredging, yes; but it would be very slight.

Senator ANKENY. What would you do with the material that you dredged?

Mr. WALLACE. Carry it out to sea and dump it. Of course you will have to have with any type of canal, whether a lock or a sea-level canal, a certain number of dredges in case bars are formed at the mouths of streams that enter the canal, where they are not properly diverted, or to take care of points which may shoal up, due to various causes.

Senator ANKENY. It is not a serious matter?

Mr. WALLACE. No, sir.

Senator ANKENY. It is definable, to use an earlier expression of yours?

Mr. WALLACE. Yes, sir.

Senator TALIAFERRO. And it is common to both types?

Mr. WALLACE. Yes, sir; it is common to both types. Right on that point, I have seen estimates here based on the number of cubic yards that are excavated.

Senator ANKENY. Yes.

Mr. WALLACE. Showing that it would cost a great deal more to maintain a sea-level canal than a lock canal, because a greater number of yards had been excavated to make the sea-level canal. The amount of wash into a canal does not depend upon the material that has been dug out of it to make it. It seems to me that should be very plain to anyone. What it does depend upon is the nature and extent of the washable surface and the amount of rainfall that you have. Whether you have taken out a hundred thousand or a hundred million yards of stuff to make the canal has nothing to do with the amount of dirt that is going to wash back into the canal. The surface that the water flows over, its character and extent, and the amount of rainfall are the factors that make up the amount that is going back into the canal.

Senator TALIAFERRO. And its susceptibility to wash?

Mr. WALLACE. Yes; I say, its character.

Senator ANKENY. In connection with this sea-level canal there have been many objections, which you see by the reports, to its width, and reference has been made to the difficulty of two ships passing. Suppose that the old proposition or plan was in operation, could not this widening go on without interruption of the traffic. In other words, could we carry on our traffic on a limited scale, we will say, for argument's sake, and go on with the additional work of widening without interruption of that traffic to any great extent?

Mr. WALLACE. Your canal could be widened or deepened, or anything that you please, without necessarily making any disturbance of your traffic.

Senator ANKENY. If we find it inadequate?

Mr. WALLACE. Yes, sir.

Senator ANKENY. We anticipate a great traffic there, which we have a right to do, I think, from all the circumstances; but if, in the wisdom of Congress or of the Commission, it should be widened later, it could be done without interruption of the traffic that we have; am I right?

Mr. WALLACE. You are right; yes, sir.

Senator ANKENY. If the sea-level canal was adopted, where would you put the power plant that you propose to use for lighting and power?

Mr. WALLACE. I would put it at Gamboa. That is very near to the center of the Isthmus, and is what you might call the center of gravity of the work.

Senator ANKENY. That would necessarily be this dam proposition again, would it not?

Mr. WALLACE. Yes, sir.

Senator ANKENY. Now, let us leave that and come to another point. I think by pictures, you see, and you must pardon me if I digress a little. Under which proposition the majority or the minority, or the sea level or the lock canal, which ever way you wish to distinguish them, is there the greater danger from enemies? Which type has the lesser risk, in other words?

Mr. WALLACE. It seems to me that there is no question but that the sea-level canal is the safer.

Senator ANKENY. The sea-level canal is safer than the other?

Mr. WALLACE. Much safer than the other against anything that might happen to it, either by act of God or act of man, in time of peace or war.

Senator ANKENY. A sea-level canal would be the better plan, for that?

Mr. WALLACE. Yes, sir.

Senator ANKENY. Now again I will digress a little. What is your estimate of the submerged lands, under the lock proposition? Have you made any?

Mr. WALLACE. Well, that is a very difficult matter to make an estimate about.

Senator ANKENY. I know it is difficult, but it has to be fixed.

Mr. WALLACE. While the franchise or the law says that that valuation shall be the same as it was before we took possession, those things do not work out that way in practice.

Senator ANKENY. Not in their courts.

Mr. WALLACE. Not in their courts nor in our courts down there. We wanted to get some land right up alongside of Ancon here that belonged to a man named Diaz. General Davis can tell you the details about it. I do not remember them all. That property I do not believe cost that old gentleman over \$5,000. When we went down there it was not worth over \$5,000. He could not have sold it to a Panamanian for over that.

We had a commission come down there from the States, under the law; they formed part of it and we formed part of it. We had two

men coming down from the States, joined with the Panamanians. I do not remember certainly, but my recollection is that the valuation on that property was about \$50,000—about ten times what it was supposed to be worth. We tried for months—General Davis did—to buy some property at Corozal that belonged to the Shubers, that had been in litigation with the old French canal company, and they wanted a thousand dollars an acre for this land that was what we call manglares or swamps [indicating on map], lands that we did not think were worth over \$5 an acre.

Senator ANKENY. We had a specimen of that in your hospital matter there, if you remember it.

Mr. WALLACE. Yes, sir.

Senator DRYDEN. They are becoming Americanized, I see. [Laughter.]

Mr. WALLACE. They are, very, very rapidly. [Laughter.]

The result was that at Corozal I was not able to utilize ground that was very suitable for buildings. There were buildings on it that the French had there, and we went in and arbitrarily fixed them up and put our men in them. It was maintaining a status quo. We did not put any new buildings on that property.

In this territory down here there are banana plantations [indicating on map].

Senator ANKENY. And they will be submerged?

Mr. WALLACE. Yes, sir.

Senator ANKENY. Under the lock system?

Mr. WALLACE. Yes, sir. And these towns existing along the Panama Railroad [indicating on map].

Senator ANKENY. Approximately, what damage will this Government have to pay if we take those people's lands? That is a hypothetical question, but we want to know that.

Mr. WALLACE. From my knowledge of the people down there and the way they work—I mean the way they work us [laughter]—

Senator ANKENY. That is the difficulty.

The CHAIRMAN. They do work us, too. [Laughter.]

Mr. WALLACE. They do. On the whole situation, I should judge it would cost \$25,000,000 to pay for the land which will be submerged by that 85-foot dam project on the lock plan.

Senator ANKENY. I understand that you would recommend that this be done under the contract system?

Mr. WALLACE. Yes, sir.

Senator ANKENY. That is unequivocal?

Mr. WALLACE. The object of that is this: Simply to get it so that one man can be put down there and do it.

Senator ANKENY. I understand.

Mr. WALLACE. That is all. If we could do that work the way a railroad company or a private corporation would do it, why I would not say so; but from my experience with it, from the utter impossibility of the United States Government carrying on a constructive enterprise in a common-sense, business-like manner, it looks to me as if the only way there was out of it was to put it in the hands of a general contractor. Then, that general contractor, having no interest in it except to get it done, and as quickly as possible—

Senator ANKENY. And to get his money?

Mr. WALLACE. And to get his money, can put a man in charge of that work there, and can use methods which it is impossible for us as a Government to use.

Senator MORGAN. Would you turn over the railroad to the general contractor?

Mr. WALLACE. The whole business, lock, stock, and barrel.

Senator MORGAN. How would you arrange about the commercial traffic on the railroad between the seas?

Mr. WALLACE. The great business of the world is carried on by private railroad corporations to-day; and it would be the easiest thing in the world to specify the rates that that contractor shall charge, and you can hold him to his duties as a common carrier a great deal easier than you can hold one of the transcontinental American railroads to its duties as a common carrier. And the proposition is so simple; it is simply taking freight from one dock and landing it on another 47 or 50 miles away.

Senator MORGAN. And having the control of the railroad he could conduct his canal work without injury to the commerce?

Mr. WALLACE. Without any injury to the commerce whatever; and he should be required to do that. If we are spending three hundred millions of dollars to afford the world an uninterrupted line of traffic across that Isthmus at the lowest possible rate, and we can do that through that railroad, and do it now, why should we not use that railroad for that purpose? And as the contractor's work is to be to accomplish that result, he should be required to do it as he goes along, and there is no reason why he could not do it. That railroad is capable of handling and can be made capable of handling any amount of tonnage that will ever pass through that Isthmus, and doing it quickly and doing it economically.

Senator MORGAN. I would like to ask you whether there is not still some complaint in regard to the railroad rates across the Isthmus?

Mr. WALLACE. I do not know. I have not been in touch with it lately, Senator.

Senator MORGAN. I gather my information from the common source of information in this country—the newspapers.

Mr. WALLACE. What I understand is this: The rates across that Isthmus were made in this wise: There was through billing from New York to San Francisco by the way of the Panama Railroad Steamship Line and the Panama Railroad to the Pacific Mail. That rate was very low, and the average rate across the Isthmus, as nearly as I could figure it when I was there, was about \$1.92 a ton. In other words, the competition of the transcontinental railroad lines forced the Panama rate down to that figure. The Panama Railroad did not regulate the rate of the through transcontinental lines, but the through transcontinental lines regulated the rate that the Panama Railroad could charge. They could only get what they could out of what was left.

Senator MORGAN. That was very natural, because they control it!

Mr. WALLACE. Yes; all of the ports along the western Pacific coast; each of them bore a different rate across the Panama Railroad. For instance, the railroad rate was dependent upon what the stuff was and where it came from. In other words, coffee from one port might bear \$6 a ton and from another port \$4 a ton for its passage across the railroad. What regulated those rates was what it cost to take that stuff

around Cape Horn. In other words, the Panama Railroad charged on that traffic what that traffic would bear, up to the last mill.

I understand those rates have been cut in two, and there have been some minor adjustments, but there is no reason why that service should not be rendered to everybody, and to everybody alike, and there is nothing that you are going to do to develop our trade relations with those South American countries that will help out any more or any better than to make out the lowest possible rate that you can on the railroad across that Isthmus and let those people have the benefit of it. That will develop their country and their purchasing power and increase our trade.

Senator MORGAN. The railroad is under the operation and control of a New York corporation?

Mr. WALLACE. Yes, sir.

Senator MORGAN. That corporation fixes all the rates?

Mr. WALLACE. Yes, sir.

Senator MORGAN. The Commission does not fix the rates; can not fix the rates?

Mr. WALLACE. Yes, sir.

Senator MORGAN. It has been the work of the corporation?

Mr. WALLACE. Yes, sir.

Senator MORGAN. So that the officers of that corporation are the most important officers on the Isthmus to-day connected with the movement of commercial business, and also supplies to the Isthmus of every kind that are necessary to conduct the canal work?

Mr. WALLACE. That is true. And the officers that control the railroad in New York, with very few exceptions, have never been down there. They do not know what they have got.

Senator MORGAN. In the contract plan that you suggest, it would be necessary to put the control of this railroad, rates and all, in the hands of the contractor, seeing that he did not charge too much?

Mr. WALLACE. Yes, sir.

Senator MORGAN. That would be the programme?

Mr. WALLACE. Yes, sir. There is one thing I want to say, if you will pardon me for mentioning it, and that is that the United States Government and myself are the only stockholders in the Panama Railroad. I bought a share of stock in order to qualify myself as a director in the Panama Railroad. I gave the United States my check for it. They bought back an option on that stock, and took my check and cashed it. And they have got my money and they have got the stock. [Laughter.]

Senator MORGAN. The Government seems to be doing pretty well in the railroad business. [Laughter.]

Mr. WALLACE. But, technically, I happen to be the only stockholder of the Panama Railroad, except the United States Government.

Senator MORGAN. You delivered up your share of stock, did you not, to the Government?

Mr. WALLACE. The Government has it.

The CHAIRMAN. And your money, too? [Laughter.]

Mr. WALLACE. Yes, sir. But that, of course, is neither here nor there.

Senator MORGAN. So that, if you were really a stockholder in the Panama Railroad Company and also a director, you would have a very potential voice in the management of the rate question?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And they would not get away from you, would they?

Mr. WALLACE. Not if I had influence enough to do anything.

Senator ANKENY. There is one other point that I had in my mind that I wanted to ask you about: In advocating the contract system, which I understand you do, how would you dispose of your plant; I mean your machinery, your shovels, etc., which belong to the Government. What would be your suggestion?

Mr. WALLACE. I would turn them over to the contractor.

Senator ANKENY. Everything?

Mr. WALLACE. I would turn everything down there over to him—your shops, your old machinery, and your new machinery, and everything else.

Senator ANKENY. If either type of canal were completed (we will call them, for convenience, the lock and sea level), what, in your opinion, would be the cost of maintenance? Which would be the greater expense to this Government, or which could we maintain easier?

Mr. WALLACE. Of course, it is a very difficult matter to figure on those expenses.

Senator ANKENY. I know it.

Mr. WALLACE. But I should judge you would save at least a million dollars by the sea-level canal; that it would be at least a million dollars cheaper per annum to maintain.

Senator MORGAN. Per annum?

Mr. WALLACE. Yes, sir; per annum.

Senator DRYDEN. That makes no allowance for the capital invested?

Mr. WALLACE. None whatever.

The CHAIRMAN. I think we had better take a recess until 2.15.

Senator TALIAFERRO. There is one question that I wish to ask, Mr. Chairman.

The CHAIRMAN. Very well, Senator.

Senator TALIAFERRO. You spoke of the estimated cost to the Government of these lands that would be submerged by the lake in the lock-canal plan. What have you to say about the lands that would be submerged by the Gamboa dam?

Mr. WALLACE. The difference is simply this: There is a very small population in the Chagres Valley above Gamboa, and the larger part of the population in the Zone is in the valley below Gamboa. You will find that, as a rule, the more numerous and the smaller the holdings are, the more trouble you will have with them.

Senator TALIAFERRO. As a matter of fact, does not the Government own more of the land than would be submerged by the lakes in the lock plan than they do in the upper Chagres Valley that would be submerged by the Gamboa dam?

Mr. WALLACE. I doubt it. Those titles are very much involved. We supposed that we got from the treaty a sufficient amount of land between La Boca and Corozal. We supposed that we had that. At least I understand that that was General Davis's view and Judge Magoon's view. But we found, when we commenced to dig into it, all sorts of complications in regard to the title. So I think you will find, when you get at it, that whenever there is any particular piece of land that you want that the Government does not own it in such a way as to relieve you from having to pay somebody else for it, just the same.

Senator TALIAFERRO. Have you made any estimate at all of the acreage that would be submerged by this Gamboa dam?

Mr. WALLACE. No, sir; I told you that was just simply a round, off-had guess—that 25,000,000.

Senator TALIAFERRO. I am speaking of the Gamboa dam.

Mr. WALLACE. That depends on the height of water that there will be. I have not the tables with me, but that is worked out in a set of tables showing the area at different heights of water. It is very easily determinable though.

Senator MORGAN. The amount above the Gamboa dam at the time of the Hay-Varilla treaty was made had very little value.

Mr. WALLACE. That is true, both above and below; but there is very small population above Gamboa. I have been up there, and after you get away from the river it is simply a jungle for miles.

Senator MORGAN. And steep hills?

Mr. WALLACE. And ravines that ramify in all directions. This shows it, approximately [indicating on map], all these depressions you see. There are no inhabitants up in here [indicating on map]. Occasionally, at these little towns, there will be one or two or three families in thatched huts.

Senator MORGAN. There is a little village between Gamboa and Alhajuela, is there not?

Mr. WALLACE. Yes, sir; but it is practically a wilderness after you get above Cruces there.

(The committee thereupon took a recess until 2.15 o'clock p. m.)

AFTER RECESS.

STATEMENT OF JOHN F. WALLACE, ESQ.—Continued.

Senator KITTREDGE. Mr. Wallace, what is the character of the material under the dams at La Boca, Sosa Hill, and from Ancon Hill to Corozal, as proposed by the minority?

Mr. WALLACE. I can explain that to you better from reference to one of these maps. At the mouth of the Rio Grande these are mud flats; and the mud, I understand, depending on the depth of the water, is all the way from 25 to 55 or 60 feet in depth—a soft mud or ooze.

In between Sosa and Ancon, of course, there is rock at a moderate depth, but there is soft material in the line of the other dam between Corozal and Ancon. The cross sections of those dams, as shown by the minority report, of course show those depths, but the situation is a little different from what it is at Gatun, on account of the fact that underneath all of this soft material there is practically a bed rock, and the dam is of a more moderate height. It is to contain about 55 feet of water. The difficulties in the way of its stability are, of course, much less than they are at Gatun, but they consist of this: If you put any weight on that soft mud the soft mud is pressed out from under the weight that you put on it, and before you get a stable structure the entire area of soft mud will have to be pushed out from under the dam. If any of that soft mud should be contained in it in a pocket any undue pressure on one side of the dam or the other might cause the pressure of that soft mud to operate along the lines of hydraulic pressure and might impair its integrity at some time.

In other words, it is necessary, at the La Boca dam, that all of that soft mud be removed by some process or other, either by filling in the hard stuff in the center each way and pressing it out each way, or else by its removal by dredging or pumping, before the dam is constructed.

Senator KITTREDGE. How do the conditions that you have described in regard to the location of the dam at La Boca, as proposed by the minority, compare with the conditions in the railroad construction across Salt Lake?

Mr. WALLACE. They are practically similar to what we would find in a place like the Lucene cut-off, where the Union Pacific Railroad built its line across the Salt Lake; and it is a condition that you frequently meet with where you build railroad embankments across marshes. That is, you never get stability of a railroad embankment across a foundation of that character until the soft material has been eliminated in some way or other.

Where you have a hard surface below, what occurs is that the weight on the soft surface will push that soft stuff up. It may be 100 or it may be 500 or it may be 1,000 feet away, and it will come up at some other place. But if you will notice the cross section that is shown of that dam it is several hundred feet across, and before that dam can be brought to a state of stability all of that soft mud underneath it will have to be eliminated, either by crushing and pushing it away or else by dredging, before the dam is constructed.

My understanding from my reading of the minority report is that they intend simply for the embankment to be built in that material, and that material to be compressed by it.

Senator KITTREDGE. This morning a suggestion was made, or a question was asked, concerning a sea-level canal from the Atlantic to the vicinity of Obispo, from the Pacific to the vicinity of Miraflores, and a lock structure or canal between the points Obispo and Miraflores. How much less money would it cost to construct a canal along those lines than a sea-level canal?

Mr. WALLACE. Of course that, Mr. Senator, would depend upon the details of the plan; but I presume that there would be a difference of possibly \$50,000,000 between those two plans—that is, in round numbers.

Senator KITTREDGE. That is an estimate, as I understand you?

Mr. WALLACE. Yes; that is simply an off-hand estimate.

Senator KITTREDGE. I wish you would tell us in regard to the difference in time of construction between the two plans proposed by the Board of Consulting Engineers and the minority.

Mr. WALLACE. My own estimate is that I know of no elements in that problem that could possibly make that length of time longer than about three years. That is predicated on the supposition, if you will pardon me, that the excavating of the central divide is the controlling element.

Now, personally and individually, I doubt very much whether or not these large locks, with the immense amount of concrete and structure that has got to be put in by labor more or less skilled, and put in in forms, and depending upon material coming there just in right quantities at the right time, I doubt very much whether the central excavation could not be taken out at Culebra for a sea-level canal as soon as these immense locks could be constructed. It is an open ques-

tion in my mind. I think the minority have underestimated the time it will take to construct those locks.

Senator KITTREDGE. Mr. Stearns or Mr. Noble, or both of them, in their testimony given to us last week, said that it would require fifteen years to construct the sea-level canal.

Mr. WALLACE. Of course there is one thing I would like to remark, if I can do it without egotism, and that is this: I do not know of any of the engineers that have been connected with this work, on either the regular Isthmian Canal Commission or the Advisory Board, that have had any large amount of experience in handling steam shovels and railroad trains and the disposition of material. I think I can honestly say that I have had more experience than all of those men put together in the handling of excavated material by train and by steam shovel, and the proposition for a sea-level canal is simply "dig, dig."

Senator SIMMONS. Do you include Mr. Stevens in that statement?

Mr. WALLACE. No, sir; I do not. Mr. Stevens is a man that has had a great deal of experience in railroad work, and his experience I think more nearly meets my own than any of the other engineers connected with that work. He is a man for whom I have the highest respect; but I do not know what his experience has been in steam-shovel work, except that I know that he has had a very large and long railroad experience. But I have had a peculiar kind of work that very few engineers have had, and that has been in the shape of grade-reduction work, double tracking, and the work of excavating large quantities of material and disposing of it along and adjacent to operated lines of railroad.

This proposition at Culebra, as far as a sea-level canal is concerned, is practically a railroad proposition. It is just the same as if you were relocating the Panama Railroad and reducing its grades, making a big, heavy cut along its line, using that line as one of the instruments to do your work with; and whether you run a railroad through the bottom of that excavation after you get it done, or whether you let water in it and float steamships through it is entirely immaterial. But the sea-level proposition, as far as that central cut is concerned, is simply a railroad proposition.

Senator KITTREDGE. And what do I understand you to say about the fifteen-year period suggested by Mr. Stearns and Mr. Noble?

Mr. WALLACE. I said I thought it was too long.

In the appendix to the report of the Advisory Board, I furnished that Board a series of diagrams that took the heaviest half-mile section there was there and showed exactly how I would place steam shovels to do that work, how I would arrange the tracks to serve them, and the cars to serve them, the different dates at which steam shovels could be installed, when the first steam shovel could be installed, and when the last would be, and a scheme covering that whole work, on a tentative basis—that is, on the basis of those steam shovels handling 1,000 yards per day and working twenty days in the month. I also made a similar diagram on exactly the same principles for a 60-foot level canal; and the difference between the two figured out, I think, less than two years and a half.

It may not be clear to the members of the committee, but it is a fact that the length of time that it will take to do that work is not in proportion to the amount of yards to be moved. The length of

your cutting affects it and the width of your cutting. It is not as if you were digging a ditch with a spade. That work has to be begun by putting steam shovels in along terraces. The more terraces you get and the wider your cut is the more steam shovels you can work at the same time. So, from the date of commencement for about three years you will be continually adding shovels, and then you will be working for a few years the same number of shovels, and then you will work gradually less and less until you get down to the bottom. In other words, the difference between the rate of progress is affected by the amount of what you can do in the maximum year and not by your average per year.

I do not know whether I have made that matter clear to you or not.

For instance, on the 60-foot plan, say that the first shovel started in January, 1906; the last shovel would complete its work in August, 1912. That is on that supposition. On the sea-level plan, which you will find in this report, my recollection is that the time was a little under nine years.

Senator KITTREDGE. I wish you would call attention to the page when you find it.

Mr. WALLACE. That diagram is diagram No. 3, and you will find it between pages 373 and 374. On the sea-level plan, with the first shovel starting on the 1st of January, 1906, the last shovel completes its work in December, 1914. That is practically nine years.

This diagram shows exactly the dates on which every shovel will start; and while this is only a tentative plan, it is one that a contractor would expect to exceed in efficiency rather than fall below it. A thousand yards a day is about one-fourth of the loading capacity of those large steam shovels that are now on the Isthmus, in ten hours, provided they are properly served with cars and the material is properly blasted ahead of them. In other words, to get that result you will only have to work those machines to 25 per cent of their capacity, and do it for twenty days in the month.

Senator KITTREDGE. Is there any difficulty in doing the blasting work necessary to serve the shovels to that extent?

Mr. WALLACE. No. Of course that is something that has to be looked after. The limitation on all steam-shovel work, as a rule, is the arrangement of the tracks and having plenty of tracks and plenty of cars, and seeing that your shovels are continuously fed. I got out as high as 1,800 yards in one particular day with one particular shovel when I was down there. Along in the dry season it ran about 800 yards a day per shovel. The reason that we fell below the maximum was because we did not have any facilities, except the shovels, that properly went with them. That is, we did not have proper drills, and we did not have proper track. We had those old French cars and those old French engines, and our tracks were poor; we did not have any ballast for them, we were short of ties to keep them up, and in fact, we were short of everything. But in spite of all those disadvantages there were several months there in which we got from 750 to 800 yards per day out of those shovels, and I do not think it ever fell below 400 yards a day.

Senator MORGAN. In the dry season or the wet season?

Mr. WALLACE. That was in the dry season.

Senator MORGAN. All of this?

Mr. WALLACE. I say, in the worst month we had, in June, it dropped down to about between 400 and 500 yards a day per shovel. That was when we had 25 or 30 derailments every day; when the men were so discouraged on account of the engines getting off the track that they did not see why we should continue the work.

With proper equipment and with the right kind of equipment, which you are getting down there now, I do not see why the estimate of 1,0000 yards a day per shovel is not a very low estimate.

The CHAIRMAN. Is that for ten hours a day?

Mr. WALLACE. For ten hours a day.

Senator TALIAFERRO. You were working eight hours a day, were you not?

Mr. WALLACE. I was working ten hours a day up to about the 1st of May. The last two months I was down there we worked eight hours a day, and then our capacity dropped off very much.

The CHAIRMAN. If you were to work two shifts a day, of course you would gain?

Mr. WALLACE. You would get more than that, of course?

Senator TALIAFERRO. Probably a third more?

Mr. WALLACE. Well, yes; I should say about a third more. That is, I have never yet seen work where you could do exactly double the work with two shifts that you can with one; but you can get from 50 to 75 per cent more. When I say a third more, I mean that it would be 50 per cent more. You should do that at the very least.

Senator SIMMONS. Do I understand you to express the opinion that a sea-level canal could be constructed within nine years?

Mr. WALLACE. On this tentative plan, nine years is the time it would take from the time the first systematic installation of your shovels would commence. That is based on taking the heaviest half-mile, not the heaviest average 8 miles; because there is one half-mile which has more material in it than there is in any other half-mile, so I have taken the worst half-mile there was.

Senator SIMMONS. Do you mean it would take nine years to dig it, or that in nine years the dam at Gamboa could be finished and the canal be ready for the use of ships?

Mr. WALLACE. What I mean to say is this: That on the sea-level plan there is not any doubt but what the thing which will limit the completion will be that central cut at Culebra. You can build your dams and you can do all your dredging, your harbor work, easily within four or five years.

Senator SIMMONS. Everything else will be ready when that is finished?

Mr. WALLACE. Yes.

Senator SIMMONS. And your estimate is nine years?

Mr. WALLACE. I estimated nine years. After that I made an allowance on top of that, and said that I thought ten years would be time enough, and at all events twelve would be an ample estimate for it.

Senator SIMMONS. And it would take about three years less time to complete the lock canal?

Mr. WALLACE. Yes; that is, theoretically, I should say there was three years difference between the two plans; but I doubt very much whether that three years would not be eaten up by all sorts of happenings that would arise when you would go to build these immense locks.

Senator SIMMONS. I do not know that I understood you about those locks a little while ago. I understood you to say (and I want to ask if I understood you correctly) that you thought it quite probable that it would take as long to construct those locks as it would to build the canal by the sea-level plan. Do I quote you correctly about that?

Mr. WALLACE. Yes.

Senator SIMMONS. By the sea-level plan?

Mr. WALLACE. Yes.

Senator SIMMONS. Then, as the locks would absolutely have to be built, the conclusion would be that it would take as long to construct the lock canal as it would to construct the sea-level canal, would it not?

Mr. WALLACE. That is, I would very much doubt but what it would take about as long to build the one as it would the other.

Senator SIMMONS. Then what did you mean when you said that the lock canal could be built probably in three years less time?

Mr. WALLACE. What I said was this: I said that that was based on the time that it would take to remove the excavated material from the Culebra Cut, applying the same process to excavating for the lock canal that you would for the sea-level canal. I said that leaving out of consideration the construction of locks and dams, and only measuring your progress by the excavation of the summit cut, there would be three years' difference in doing that work. In other words, you could excavate the material from the summit about three years quicker on the high-level plan than you could on the sea-level plan.

Senator SIMMONS. Then your conclusion is that we could not get the lock canal ready for use any quicker than we could the sea-level canal?

Mr. WALLACE. I doubt very much if you could. That is the impression I was trying to convey.

Senator MORGAN. Mr. Wallace, you said all sorts of happenings might occur in the construction of the locks. To what did you refer?

Mr. WALLACE. Well, for instance, there is something like a million cubic yards of material, I understand, to be used in those locks. If those locks are constructed of concrete (which I presume is what they intend to build them out of) that means practically a million yards of broken rock; it means a million yards of sand; it means a million barrels of cement.

Those three classes of material must be manufactured and transported to the site of that work in properly related quantities. Take cement, for instance. That climate is so moist that even if cement is housed you can only keep it for a limited amount of time on the Isthmus, and it will require a great deal of care to see that that cement is brought there just fast enough for that work and not too fast. It is the same way about crushed stone; you must see that that is properly supplied.

Senator MORGAN. Would you have to bring that across the ocean?

Mr. WALLACE. The cement you would bring across the ocean; the crushed stone and sand you get on the Isthmus.

Another point: That million cubic yards of material is practically equivalent to a million tons—that is, in round figures; and on the basis of 500 tons to a train load, it means 2,000 trains. That gives you some general idea of the mass of material that will be required just for those locks alone. That means 2,000 trains of 500 tons per train, net load.

Senator MORGAN. Mr. Wallace, the cut through the Culebra and Emperador heights—that is one ridge, is it not?

Mr. WALLACE. Yes, sir.

Senator MORGAN (continuing). That has been brought down from the upper crest to about what height above sea level?

Mr. WALLACE. It is about 150 feet.

Senator MORGAN. That would be an average through, would it—150 feet?

Mr. WALLACE. No; I do not think the average for the whole 6 or 7 miles there would be much over 100 feet; but there are 2 or 3 miles there that will average about 150 feet above sea level.

Senator MORGAN. Yes; that has been cut down in trenches or terraces?

Mr. WALLACE. Yes, sir.

Senator MORGAN. The height of each terrace is about 30 feet?

Mr. WALLACE. No; those terraces are very irregular. They will all have to be worked over again in order to suit steam-shovel work. Those terraces were adapted to the French style of excavator. The terraces which I proposed in my tentative plan were terraces of about 30 feet horizontal and about 25 feet perpendicular until you got down; and then after that you would make the slopes to suit the final section you intended to leave.

Senator MORGAN. Is there any terrace on either side of the excavation as it stands now that passes on the same level or nearly the same level clear through the cut?

Mr. WALLACE. Yes; there were several when was I down there that did?

Senator MORGAN. About how high are they above where the work is now being conducted?

Mr. WALLACE. We were working on those terraces.

Senator MORGAN. So that these terraces upon which you are now operating with your steam shovels go clear through the cut?

Mr. WALLACE. That was the intention. When I left there I was starting to work different terraces through. I commenced one on the east and north of the canal that was about on the rock line, and I was taking that clay back 75 or 100 feet from the edge—the clay that overlaid it.

Senator MORGAN. Leaving out of consideration the repairs which may be found necessary to readjust the levels properly upon the terraces as they have been constructed, and taking the one upon which you are operating now with the steam shovels, you would have to go below that if you worked a steam shovel on every terrace; you would have to go below that to the bottom of the canal; and what would be the distance between the average elevation of this lowest terrace on each side and the bottom of the canal when completed 40 feet deep?

Mr. WALLACE. When I left there we were working on several terraces, and where the lowest steam shovel was at work was about 160 feet above sea level; that is, the final depth of the sea-level canal would be about 200 feet below the elevation at which the shovel was working, which was in the highest part of the excavation.

Senator MORGAN. Yes. Now, take the terrace that stands at an elevation of 200 feet above the bottom of the canal, the one you are now working on, or were working on when you left there. You would

want to put in steam shovels upon terraces from that point down to cover the distance of 200 feet to the bottom of the canal, would you not?

Mr. WALLACE. Yes.

Senator MORGAN. So that you would expect the work to progress with some degree of uniformity of breast?

Mr. WALLACE. Yes.

Senator MORGAN. And do all of the work as you went along upon each terrace. Now, you would commence at the bottom of the canal; that would be the first opening you would cut. Of course there would be no terrace there until you got up 25 feet, if you took that for the elevation of your terrace. You would have to excavate 40 feet below sea level, and about how much above, before you got through? No, you would commence with your work about 40 feet below sea level, and then you would have a terrace above that every 25 feet or every 40 feet, whatever the height might be that you would adopt for the terrace; and all of these shovels, as I understand it now, would work practically abreast, each shovel doing its own work on its own terrace. Is that right?

Mr. WALLACE. That is right, only it is a little different from the way you have stated it. The maximum number of shovels that would be at work at any one time abreast would be eight on each half mile. That is, there would be one time when there would be four shovels on each side of the cut in each half-mile of distance, because it takes about half a mile between two shovels in order to put in the necessary track arrangements so that you can get around and work all your shovels independent of each other.

Senator MORGAN. I am trying to get at and to ascertain whether this plan of construction is the one which you have adopted. The digging out of the prism of that canal would be a cut in solid rock?

Mr. WALLACE. Yes, sir.

Senator MORGAN. At least 40 feet in depth and 200 feet wide?

Mr. WALLACE. Yes; that is what you would get down to finally.

Senator MORGAN. I say, finally; I am starting at the beginning of the work.

Mr. WALLACE. I know; but we would not start there. We would start at the top.

Senator MORGAN. You would not start at the bottom?

Mr. WALLACE. No, sir.

Senator MORGAN. Why not?

Mr. WALLACE. If I had a blackboard here I could show you. For instance, say this is the sea here, and this is your hill, like that [indicating].

Senator MORGAN. Yes.

Mr. WALLACE. Now suppose the excavating to start in here—one shovel would go through there [indicating] and then another one would come in here afterwards [indicating], and then after it got in a certain distance another one would follow, and you would work from both ends toward the center, and you would work down; you would commence up here and you would gradually dig these various terraces out until you would finally reach the bottom.

Senator MORGAN. Could you construct the canal by beginning at the bottom and working up?

Mr. WALLACE. No; 'because you would have such a steep face in here that you could not get shovels enough to work in it.

Senator MORGAN. You could get how many abreast in the bottom of the canal, 200 feet wide?

Mr. WALLACE. You could probably only get four in there.

Senator MORGAN. Four?

Mr. WALLACE. Yes.

Senator MORGAN. And each one would have a separate track?

Mr. WALLACE. Each one would have its separate tracks; but when you are up here, halfway up in the cut, you can work eight abreast. Now, this diagram (if you will follow the description of these numbers) shows exactly when each shovel starts out, how much of a slice it takes, and how many slices are taken out simultaneously. It is hard to explain it by words; but, for instance, at first there would only be two shovels abreast, and they would dig a section of about 12½ feet; and they would put that material on a track that would be on the edges here. Then after that slice was taken out the tracks would be laid in behind those shovels, and these shovels, No. 2, would start in, and take out a bench that would be 25 feet or 30 feet wide, and put that material on cars that would be where the first were.

Then, after the 2's were taken out the 3's would start in and put the stuff over on tracks that would follow the second shovels, and so on with the 4's, and later on the 5's. When you got down to what we call the No. 10 shovels there would be 8 of those. Now, that is not on the immediate bench below, because it is necessary to follow the sequence through to see how they would come. That tenth shovel would be on a bench at least 75 feet wide, and there would be tracks out here where the second shovel had been, and there would be tracks where that ninth shovel was; and the 10 shovels will take out these slices that are shown on this cross section.

It is rather intricate to follow.

Senator MORGAN. What is that heavy cut in the center of your diagram there?

Mr. WALLACE. This one? [Indicating.]

Senator MORGAN. Yes.

Mr. WALLACE. That is where the shovels are worked in parallel in order to keep a central cut which will be 60 feet wide and average 12½ feet below the balance of your excavation. What we call the "pilot shovels" will be at work shoving that depression always forward, ahead of these other shovels.

Senator MORGAN. When you go down to sea level with your shovel work and want to go lower down, 40 feet lower, could you continue your shovel work?

Mr. WALLACE. Just exactly in this same way; yes, sir. The only thing we would do differently, then, would be to leave barriers. You have heard before, in the testimony, reference made to what they call "elevation plus 10."

Senator MORGAN. Yes; I know about that.

Mr. WALLACE. What they mean by that is that you can go down to an elevation of 10 feet above the sea level and have room enough for the water to flow out of your cut by gravity.

Senator MORGAN. I know.

Mr. WALLACE. But when you go below the sea level—

Senator MORGAN. It flows the other way?

Mr. WALLACE. It goes the other way, and the water stays in your cut. The only extra expense that that will be to you, if you leave the barriers in, will be the fact that you will have to pump water out of that excavation, and the extra expense will be due to pumping that water out. It is just the same as if you were working in a cofferdam.

Senator MORGAN. Now, working from the top to the bottom, after you got the different benches worked out and the material cut away to the width you wanted it, you would dispense with these shovels as you worked down?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And finally you would get down to four?

Mr. WALLACE. Yes.

Senator MORGAN. And those four shovels will have to do all of the work except the breasting?

Mr. WALLACE. Yes.

Senator MORGAN. From mean sea level down to 40 feet below?

Mr. WALLACE. Yes. That is, there are practically two furrows that are cut through where you will only have four of them at the last.

Senator MORGAN. Yes. You do not expect to employ more than four shovels in the bottom of the prism of the canal?

Mr. WALLACE. No. It is just as if you were running a gang plow through there that had four plows to it, and then you followed that with four other plows to dig it a little deeper.

Senator MORGAN. If you worked from the bottom to the top you could have all the shovels that you employed, every one upon each bench, in operation at the same time, could you not?

Mr. WALLACE. No; I do not follow you. If you had your whole canal opened out—that is, a narrow ditch from one end of your canal to the other, of the full depth—and could lay out terraces all the way along, you could work a shovel on each terrace, you understand, and you could do it all simultaneously; but that necessitates getting down first to the sea level clear through your cut, and by the time you get down there you have your work almost done.

If you were going to build a canal that was 500 feet wide or a thousand feet wide, like Mr. Bunau-Varilla's "Straits of Panama," after you got down to sea-level you could work just as many shovels abreast as you had terraces, and do it all simultaneously, and you could widen that cut out to 500 or 1,000 feet with an enormous number of steam shovels, and the depth would not make any difference, because for every additional 25 feet in depth you would have a steam shovel.

But the 200-foot width is so narrow that in order to get that face there is a time when you can work more shovels than you can at any other time, and that is about from one-third to one-half way down through the cut, and you would necessarily have to commence on top. But while you are doing this work on top, in the real work, there is no reason why you should not attack this excavation by bringing your dredged sections up to the foot of the cut on each side and working your dredges right up against this steep face and working in both directions from the sea.

Senator MORGAN. When you say "dredges," do you mean "shovels?"

Mr. WALLACE. No; I mean "dredges" in that case. In other words, while you are doing this dry cutting you are shoving your dredges in from the sea—that is, from La Boca toward the hill and from Colon toward the hill—and the supposition is that you will have your canal dug up to this point before you get this dirt all out; and you will have it dug up to this point before you get this dirt all out [indicating]. Now, while you are doing this work in the dry, as we call it, there is no reason why you should not attack this part, you understand, and push the sea-level sections just as far in toward the summit as you can get them.

Senator MORGAN. Then your plan is to dredge from the sea in to, say, Obispo on one side?

Mr. WALLACE. That is a question; just as far as you can do it economically.

Senator MORGAN. I say, dredge in from the Bay of Limon—

Mr. WALLACE. If you found rock down in here that you could not dredge, then you would want to stop your dredging here, and probably you would have to take this out [indicating] in the dry. But the probabilities are that you could get up to possibly Obispo with your sea-level section.

Senator MORGAN. There is no rock that would be encountered there that you could not dredge—by which I mean, of course, that you could blast it and haul it out, float it out, instead of hauling it out on a railroad?

Mr. WALLACE. Yes, yes.

Senator MORGAN. That is what I mean by dredging. That is a part of the dredging?

Mr. WALLACE. Yes.

Senator MORGAN. Now, if I understand it, you would start in the Bay of Limon and dredge up to, say, Obispo; then you would start on the other side in the Bay of Panama and dredge up to Miraflores, or wherever it is, there. Then, if I understand it, you would continue to take out all of the stone lying below the sea level to the bottom of the prism of the canal by this dredging process?

Mr. WALLACE. No; only up to those points [indicating]. All of the material that I could remove by what we call dry excavation between Pedro Miguel, say, and Obispo, I would prefer to remove in that way, because you can do it cheaper.

Senator MORGAN. Cheaper than you can by hauling it out on boats?

Mr. WALLACE. Yes; that is, I mean, you can blast it and mine it cheaper in the dry than you can in the wet.

Senator MORGAN. But you have to mine it in the wet when you get down 40 feet below sea level, have you not?

Mr. WALLACE. No.

Senator MORGAN. How do you manage to avoid that?

Mr. WALLACE. You leave barriers of the natural rock at each end of your cut, and then go down in between those barriers and excavate it; and then, after you get your canal section cut out, you cut away these barriers and let your water in, so that it will be a natural cofferdam.

Senator MORGAN. With an 18-foot annual rainfall, and water sluicing down from these heights, you would find that ditch full of water, would you not?

Mr. WALLACE. Oh, no, sir; because you can divide it up into sections and pump it out, and you can push that work in the dry season for four or five months of the year, when you have practically no rainfall there at all.

Senator MORGAN. Yes; and in the wet season?

Mr. WALLACE. In the wet season you have it; but in my own experience I have pumped out cofferdams that had water from 10 to 15 feet deep, 300 feet wide, and a quarter of a mile long, in twenty-four hours. The rainfall at Culebra for the year that I was down there was 75 inches—that is, for the entire year; and of course when you get down —

Senator MORGAN. How much was it in the wet season?

Mr. WALLACE. That was in the wet season and the dry—the whole year.

Senator MORGAN. It all fell in the wet season, did it not?

Mr. WALLACE. Practically. We had four months when it was comparatively dry.

Senator MORGAN. Yes.

Mr. WALLACE. Now, what any prudent man would do would be to concentrate his work and try to do as much of it as he could in the dry season.

Senator MORGAN. That is the point exactly.

Mr. WALLACE. Undoubtedly he would. But the reason the advisory board added to that and made the unit price \$1.50 per cubic yard was to give an amount that would justify pumping that water out, and with the powerful pumps that we have nowadays you could pump the full capacity of the Chagres River at low water out of that cut if you had to.

Senator MORGAN. Then you would take out—

Mr. WALLACE. Now, the only reason, Senator Morgan, that I suggest that plan is because that would be a little cheaper than to excavate that rock under the water.

Senator MORGAN. You mean by what is called the dredging process?

Mr. WALLACE. Yes. That is, you can blast it cheaper in the dry than you can under water, because you can space your holes better, you can do your drilling better, you can see the character of your rock and you can get around it and over it, and I presume that you could possibly save about a dollar a yard on doing this work in the dry rather than doing it in the wet.

Senator MORGAN. These heavy steam shovels require a strong track under them, do they not, and a well-ballasted one?

Mr. WALLACE. Yes; but the material in that cut, after you get below an elevation of about 190 or 200 feet, after you get below the clay, will stand any weight you want to put on it. The only trouble that I had down there was that I upset one of these big steam shovels, because I got it up on the side of a hill in this sliding clay, and a very hard rain came up unexpectedly; the shovel was standing over a place in the ground where there was a subterranean stream of water that ran on top of the hard material under this clay, and there was about 8 or 10 feet of clay on top, and a slide came down, and the clay ran away from under the stream on one side that the shovel was standing on, and the shovel tipped over. But that was the only accident of that kind that I had while I was down there.

Senator MORGAN. As you push these shovels against an embankment you cut in front of the shovel? The cutting is done in front of the shovel?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And then you load it onto a car?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Back of the shovel?

Mr. WALLACE. Right alongside. The idea is to——

Senator MORGAN. Alongside; so you have to have a track for the shovel and a track for the car?

Mr. WALLACE. You have to have a track for the shovel.

Senator MORGAN. And one for the car alongside?

Mr. WALLACE. Yes. Now, the track should be along on this bench here [indicating]. The shovels would be on the bench parallel to the track, against the face, and they would work a piece about 30 feet wide and about 20 feet high, and then the material would be blasted ahead of the shovel, and the shovel would work the stuff up just like you would take it up with a shovel by hand and put it over on the cars that would be parallel to it.

Senator MORGAN. Yes; I understand that now. Therefore, you have to improvise a track as your shovel advances toward the embankment you are cutting in?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And that is always in loose earth, is it not; and comparatively uncertain?

Mr. WALLACE. Oh, no, sir. Below 200 feet there is no trouble at all with that; and we had no trouble whatever, all the time I was down there, in maintaining our working tracks under our shovels. The trouble we had with our tracks was with our running tracks out on our spoil dumps, where we had to put in sharp curves and frogs and switches, and where the equipment was rigid, so that it would not go around the curves, and the track would settle because we did not have any material to ballast it with, and our trains would go off the track.

Senator MORGAN. When you got down to digging at 40 feet below sea level in these compartments we speak of, and blasting out the stuff, you could not use shovels there, could you?

Mr. WALLACE. Yes, sir.

Senator MORGAN. By putting them down on a level with the bottom?

Mr. WALLACE. Oh, yes; they would go right down on a level with the bottom. That is all hard material down in there.

Senator MORGAN. If you could use them when you got down that deep, why could you not use them before you got down that deep, by putting your shovel against this breast of rock?

Mr. WALLACE. We can; only it is not safe to work against a breast of rock that is more than about so high.

Senator MORGAN. It is not safe?

Mr. WALLACE. It is not safe. You are liable to undermine it, and you are liable to have slides, and it will come down and bury your shovels up. In other words, if you were working your shovels in that way, you would be working in what we call a through cutting. The objection to that is this: That you can not get your cars ahead of your shovel in order to load your stuff into them; you can only load one car at a time, and then you have got to take that car out and put another one in.

Now, the reason I wanted to get all these terraces clear through the cut and then start and cut one out and put it on a track, and then another one, was so that they would get the cars like this—say this was the face we were working against; the empty cars could be brought forward on that terrace and switched back on this, and could be fed right in continuously to the shovel, so that the cars would only have to be set at the shovels during the noon hours and the night and morning hours, and the shovels would never have to stop loading cars.

Senator MORGAN. The point I am trying to develop is just this—that as you go deeper into this cut, until you get to the bottom of the prism of the canal, you have to give up shovels on each side of the cut and reduce the number of working shovels, until finally you get down to four in the bottom of the canal?

Mr. WALLACE. No; not necessarily, Mr. Senator. For about three years your shovels will be put in in increasing numbers, because you will be developing new terraces. Then there will be several years that you can work the same number, and then you will work a decreasing number of shovels.

Senator MORGAN. Yes.

Mr. WALLACE. The essence of the whole matter is how to arrange that work so that you can work the greatest number of excavating units simultaneously at the fullest capacity per unit. In other words, if you can work ten shovels in each half mile and handle a thousand yards per shovel, you will make better progress than if you used forty shovels and were only getting 100 yards a day out of a shovel. So it is necessary to arrange your shovel plan so that your feed can be regularly and properly supplied to them, so that the operation will be continuous.

Senator MORGAN. Much has been said some time back, and even down almost to the present moment, about night work on the canal. Could you conduct night work on this shovel system?

Mr. WALLACE. I did not, but I could have conducted night work, and I think night work could be conducted more favorably on the Isthmus than it could be in the States.

Senator MORGAN. Why?

Mr. WALLACE. The temperature is more pleasant to work in there at night, and you can work the year round at night; and, properly lighted, there is no reason in the world why you can not work at night. At least, I know of none.

Senator MORGAN. I suppose you really mean to say that you can do night work better than you can do day work in that locality?

Mr. WALLACE. In that locality; but on the other hand, as I said a while ago, in the States I have never been able to get the same rate of efficiency out of night work that I have out of day work. One reason has been that the works have not been sufficiently lighted, and the laborers are more apt to shirk; they can get in the shadow and can not be watched as well as they can in the daytime.

Senator MORGAN. So far as I am concerned, I shall have to drop this interesting view of the subject. It is very interesting to me, because it is very instructive. It is something that I wanted information about, and I suppose the balance of the committee would like it; but I want to ask you some other questions and then let other gentlemen go into this matter.

You were first appointed chief engineer of the canal. That was your first appointment?

Mr. WALLACE. Yes, sir.

Senator MORGAN. What was the date of it?

Mr. WALLACE. June 1, 1904.

Senator MORGAN. When did you arrive on the Isthmus?

Mr. WALLACE. I arrived on the Isthmus in the latter part of June. I do not recollect the date.

Senator MORGAN. How long did you remain there before you came back to the States?

Mr. WALLACE. I came back in the latter part of August or the first of September. I do not remember the exact date.

Senator MORGAN. Were you appointed a Commissioner before you came back?

Mr. WALLACE. No, sir; I was appointed a Commissioner in the following spring.

Senator MORGAN. The following spring?

Mr. WALLACE. In April, 1905.

Senator MORGAN. Yes. You remained chief engineer, then, from June until April?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And then you were made a Commissioner?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Where were you when you were appointed a Commissioner?

Mr. WALLACE. I received my appointment in New York; that is, it was handed to me in New York, by Mr. Cromwell, after my arrival from the Isthmus.

Senator MORGAN. What was the object of your return to the United States at that time?

Mr. WALLACE. I was ordered here by the Secretary of War.

Senator MORGAN. For any particular purpose?

Mr. WALLACE. In order to assist in the reorganization of the Panama Railroad or for a general conference.

Senator MORGAN. The reorganization?

Mr. WALLACE. Yes. You know the members of the new Commission were made directors of the Panama Railroad. I was never told what the object was in my coming to the States. I was very busy at the time.

Senator MORGAN. Did you have any connection with the Panama Railroad before you were made a Commissioner?

Mr. WALLACE. None, except that they tried to appoint me general superintendent of it, and I declined.

Senator MORGAN. You declined?

Mr. WALLACE. Yes.

Senator MORGAN. And did not accept the duties of the office at all?

Mr. WALLACE. I performed the duties under protest, after receiving instructions from Admiral Walker to do so. As I set forth in my previous testimony, the notice of my appointment as general superintendent of the Panama Railroad came first from Mr. Cromwell.

Senator MORGAN. Your notice came from him?

Mr. WALLACE. My notice came that I was appointed. Then it came from Mr. Drake, the vice-president of the Panama Railroad; and as Admiral Walker, the chairman of the Isthmian Canal Commission, was

the only person to whom I was supposed to report, I naturally cabled him and asked him for instructions. That correspondence is all set forth in the testimony that I gave when I was before your committee the last time.

Senator MORGAN. The position of superintendent of the railroad was tendered to you without your application?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And you declined it at first?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And who persuaded you to take it?

Mr. WALLACE. Admiral Walker practically told me that I could perform those duties temporarily. In declining it, in writing to Mr. Drake, I said that as somebody had to perform the duties I was willing to perform them, but I would do it under protest until the annual meeting of the stockholders and the board of directors, when, if they desired me to run the Panama Railroad, I wanted to be put in the office of general manager or vice-president.

The reason that I objected was this: No man can serve two masters; and if I should have taken that position as general superintendent, my line of report would have been through Mr. Drake, of the New York office, who was not a United States officer at all, and I would have been serving two masters. I would have had to go to a man as my source of authority that had never been on the Isthmus, and did not know anything about the Panama railroad except what he got from letters and cablegrams; and, more than that, I did not feel that there should be that divided responsibility. I mean, that I should not serve two masters.

Senator MORGAN. Is there any such office as general superintendent provided in the charter of the Panama Railroad Company?

Mr. WALLACE. I do not know.

Senator MORGAN. You never did know?

Mr. WALLACE. No.

Senator MORGAN. And do not know yet?

Mr. WALLACE. No.

Senator MORGAN. How long did you perform the functions or duties of general manager of that railroad?

Mr. WALLACE. Nominally from some time in April—I do not recollect the exact date of that reorganization—until about the 28th of June.

Senator MORGAN. You say “nominally.” Why do you use that word?

Mr. WALLACE. Simply because I did not get back on the Isthmus again, right in direct connection with the road, until in the latter part of May.

Senator MORGAN. Then you never have been in actual charge as general manager of this railway?

Mr. WALLACE. I was, yes; during that period.

Senator MORGAN. You had the actual charge of it?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Did you give your attention to it?

Mr. WALLACE. I gave it what attention I considered was necessary while I held that position, while I was there.

Senator MORGAN. You were not then a stockholder?

Mr. WALLACE. Yes, sir; I was.

Senator MORGAN. You had one share of stock?

Mr. WALLACE. I had one share of stock. Each one of us bought one share of stock and gave our check for it.

Senator MORGAN. Yes.

Mr. WALLACE. And then we gave the Secretary of War, I think it was, an option on that stock to buy it back again.

Senator MORGAN. Was that share of stock sold to you for the purpose of qualifying you as general superintendent?

Mr. WALLACE. No; as a director.

Senator MORGAN. As a director?

Mr. WALLACE. As a director; yes.

Senator MORGAN. But at the time of your appointment as general superintendent, or as general manager, rather, I will call it—I believe that is what you call it—you had no share of stock?

Mr. WALLACE. Yes, sir; I did. First we met in the New York office, and under the directions of the Secretary of War, Mr. Cromwell and, I think, Colonel Edwards, voted the stock and elected us directors. Then, after we were elected as directors by the stockholders, I was elected vice-president and general manager by the board of directors. That was the sequence.

Senator MORGAN. Oh, yes—all at the same time, in New York?

Mr. WALLACE. All at the same time, in New York.

Senator TALIAFERRO. From whom did you get your share of stock, Mr. Wallace?

Mr. WALLACE. I do not know where it came from. I gave my check to the Secretary of War.

Senator TALIAFERRO. Personally?

Mr. WALLACE. Personally. That is, it was made out to William Taft.

Senator TALIAFERRO. To whom did you deliver your check?

Mr. WALLACE. I delivered my check to Mr. Cromwell, I think.

Senator TALIAFERRO. Who delivered the stock to you?

Mr. WALLACE. The stock was never actually delivered to me. The stock was produced at that meeting, and then I reassigned that stock—I think I signed it in blank; I do not remember who it was assigned to—and gave the secretary an option to purchase that stock back from me. I think it was \$10 that he paid for the option. So that in the railroad offices at New York was retained the share of stock and the option, you understand.

Senator MORGAN. Did he pay you the \$10?

Mr. WALLACE. They paid me the \$10; yes, sir.

Senator MORGAN. That is all you ever got out of it?

Mr. WALLACE. That is all I ever got out of it. My check came back, though, all right, indorsed; that is, I found it.

Senator MORGAN. Who was the most prominent and most active person in having you, then, forced into office, first as a director and afterwards as general manager?

Mr. WALLACE. That was all understood; that was talked over at Washington before we went over to New York.

Senator MORGAN. Talked over by whom and with whom?

Mr. WALLACE. It was talked over by the secretary and the chairman and Magoon and I—that is, as to how we should reorganize this railroad company.

Senator MORGAN. Was that before you came up from the Isthmus?

Mr. WALLACE. No; that was after I came up here, in April, and I said I wanted the control of the railroad on the Isthmus. It was understood between us that Mr. Shonts would be put in as president and would handle the railroad and steamship line in this country, and that I would be made vice-president and general manager and would handle the railroad on the Isthmus.

Senator MORGAN. You never were made vice-president?

Mr. WALLACE. Yes; I was made vice-president.

Senator MORGAN. Vice-president—is that the same office you call general manager?

Mr. WALLACE. Vice-president and general manager.

Senator MORGAN. Yes. When did your term of office as Commissioner begin?

Mr. WALLACE. That was about the 1st of April—the first week of April.

Senator MORGAN. These transactions of making you vice-president and general manager and Commissioner were practically simultaneous?

Mr. WALLACE. No; that was a week or two afterwards.

Senator MORGAN. That you were made vice-president or general manager?

Mr. WALLACE. Yes. My commission as Commissioner was signed by the President, and Mr. Cromwell met me, when I came up from the Isthmus, in New York, and I was taken to his office and sworn in as a Commissioner and my commission given to me.

Senator TALIAFERRO. By Mr. Cromwell?

Mr. WALLACE. By Mr. Cromwell. Now, then, I was a day or two in New York, and when I came over to Washington we had our conference about what to do with the Panama Railroad. Then a little later we all went back to New York and reorganized this Panama Railroad by the new directors coming in and the old directors going out. That was a week or two weeks later, and I do not recollect how much time elapsed between those two transactions.

Senator MORGAN. Where were you when you were first informed that you were to be or had been made a Commissioner?

Mr. WALLACE. I got the first information that I had from Mr. Cromwell.

Senator MORGAN. Where?

Mr. WALLACE. In New York.

Senator MORGAN. You did not know that you would be made a Commissioner until you got to New York?

Mr. WALLACE. Yes; yes. The Secretary wired me on the Isthmus?

Senator MORGAN. How; by telegram?

Mr. WALLACE. By cable, and told me what the scheme was, and asked me what I thought of it.

Senator MORGAN. And part of the scheme was to appoint you Commissioner?

Mr. WALLACE. Yes—that the scheme was to appoint me Commissioner and put me on the executive committee.

Senator MORGAN. And also to make you general manager of the railroad?

Mr. WALLACE. No; nothing was said about the railroad at all. That all came afterwards.

Senator MORGAN. At that time that was all there was of it?

Mr. WALLACE. Yes.

Senator MORGAN. Had you ever made any application to be appointed a Commissioner?

Mr. WALLACE. No, not in that way, except in this way: When I had my first talk with Admiral Walker, at the start, I said to him: "Now, Admiral, I don't know how this thing is going to work out. You may not be able to carry out this arrangement; I may be dissatisfied down there, or you may be dissatisfied with me, or my health may not stand it, or a great many things may occur. Now," I said, "the majority of these Commissioners are men of considerable age, and there will undoubtedly be a vacancy in this Commission inside of the next year or two or three years.

"Now," I said, "I don't want you to pledge that you will recommend to the President to make me one of these Commissioners; but," I said, "if you could do so it would give me a chance after I got that work organized and started to come back to the States here and serve on the Commission; and I think the experience that I would get down there would make me a valuable member of it. But," I said, "I simply want to tell you what is in my mind. I do not want to ask you to commit yourself;" and the Admiral, as I understood him, said that he thought it would be a very good plan. That is the only conversation that I recollect I ever had about going on the Commission. That is, I mean, I never applied for it.

Senator MORGAN. And you never asked anybody to recommend you?

Mr. WALLACE. I do not think I ever did; at least I have not any recollection of it.

Senator TALIAFERRO. Did anyone ever tell you that they meant to recommend you?

Mr. WALLACE. I do not remember of any person telling me that they intended to recommend me. Of course there is this thing: I presumed after I got down there that that would be a logical step a little later on.

Senator MORGAN. I suppose, from the statements you have made, that you had in mind an expectation that after you had gotten the engineering work thoroughly under way you would prefer not to live in the Isthmus on account of your family; and you were looking forward then to falling back upon the position of a Commissioner, not required to live in the Isthmus, rather than to retain the position of chief engineer, who was required to live there? Was that the idea?

Mr. WALLACE. Yes; that was in my mind.

Senator MORGAN. Was it strongly in your mind?

Mr. WALLACE. Yes, sir; it was so strongly in my mind that that was why I had this preliminary conversation with Admiral Walker.

Now, what may have occurred is this: Different men may have at times said to me something like this: "Why, Wallace, you ought to be a Commissioner," or something of that kind, and I might have simply smiled and passed it off with some remarks. But I never made any effort to get on the Commission.

Senator MORGAN. After you were notified that you were going to be a Commissioner, you came to New York?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Soon after?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Within a few days—ten or fifteen days?

Mr. WALLACE. Yes.

Senator MORGAN. And then you met Mr. Cromwell, or Mr. Cromwell met you?

Mr. WALLACE. Yes, sir; he had his secretary meet me at the boat with a carriage, and he took me to his office where Mr. Cromwell was waiting for me.

Senator MORGAN. Who was his secretary?

Mr. WALLACE. I do not remember his name.

Senator MORGAN. When he met you, did he advise you at once to qualify as commissioner?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Was that after he had delivered to you your commission?

Mr. WALLACE. That was simultaneous.

Senator MORGAN. He brought the commission to you, signed by the President?

Mr. WALLACE. Yes; and they swore me in as Commissioner. I took the oath there.

Senator MORGAN. And it was administered in his office?

Mr. WALLACE. In his office; yes, sir.

Senator MORGAN. What reason did he assign to you for desiring that the oath should be administered at once?

Mr. WALLACE. He simply said that the Secretary desired that I be sworn in as soon as I landed. He said he did not know what business might come up in which it might be necessary for me to take action, and that they thought it would be better that I be sworn it at once.

Senator MORGAN. In your former examination you stated this, as I remember, that he said to you that he wanted you to be sworn in before you saw Shonts.

Mr. WALLACE. No, no; you misunderstood me. He said that Mr. Shonts was in the city, and Mr. Shonts and I might want to get together and transact business, and that the Secretary wanted me sworn in as soon as I landed.

Senator MORGAN. Did he make a point on that—that as soon as you landed you should be sworn in?

Mr. WALLACE. Well, it was immediately, and he had the carriage there waiting to take me to his office, although it was at night, and he seemed to attach a great deal of importance to having it done right away. I never questioned it at all. I understood that he maintained close confidential relations to the Secretary, and I presumed that he was carrying out the Secretary's will and instructions.

Senator MORGAN. Up to that time Mr. Cromwell had close, confidential relations with you, too, did he not?

Mr. WALLACE. Well, we were always friendly.

Senator MORGAN. Yes; up to that time?

Mr. WALLACE. Yes, sir; we have always been friendly since. We have had no—

Senator MORGAN. You have not fought each other?

Mr. WALLACE. We have not fought each other; no.

Senator TALIAFERRO. You knew Mr. Cromwell for some time before you took this position on the Isthmus?

Mr. WALLACE. I never met him until I met him when he appeared before the Commission to lay that bill of extras before it, in June, 1904.

Senator MORGAN. After you were appointed a Commissioner, you then came to Washington and participated in the reorganization of the Canal Commission?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Which of the old members had gone out?

Mr. WALLACE. All except Major Harrod. All of the old Commissioners were eliminated except Major Harrod, of New Orleans. He was retained on the new Commission, and he is there yet.

Senator MORGAN. Was he reappointed, or just retained?

Mr. WALLACE. I do not know. I suppose he was reappointed.

Senator MORGAN. Had the former Commission resigned?

Mr. WALLACE. I do not know about that, although they were not there in office when I came back.

Senator MORGAN. Was it the understanding that they had resigned?

Mr. WALLACE. I did not have any understanding about it, Senator. They were simply eliminated; I do not know how or why.

Senator MORGAN. Was any cause ever assigned during these interviews, in your hearing, for the unanimous resignation of the former Commission?

Mr. WALLACE. No; I never heard any particular cause.

Senator MORGAN. Do you know any reason for it now?

Mr. WALLACE. No, sir.

Senator MORGAN. Had there been any delinquency, within your knowledge—for you had worked there several months with them and under them as chief engineer—had there been any delinquency on the part of either of them so far as you knew?

Mr. WALLACE. The only criticism that I ever made, directly or indirectly, on that Commission, was the general criticism that you could not expect to get efficient executive action out of any body of seven men.

Senator MORGAN. It was too large?

Mr. WALLACE. It was too large.

Senator MORGAN. There were too many of them?

Mr. WALLACE. There were too many of them.

Senator MORGAN. Was it a case of too much talent or too much energy, or what was it?

Mr. WALLACE. There were too many differences of opinion, and the body was too cumbersome for an executive organization.

Senator MORGAN. But you went into a commission that contained the same number?

Mr. WALLACE. Yes.

Senator MORGAN. Was that too cumbersome? What is your opinion about it?

Mr. WALLACE. The impression created in my mind from the things that I heard was that in that new Commission the four members of it who were engineers were only to exercise what you might call advisory functions. In other words, there was an Executive order issued in connection with the organization of the new Commission, which is a matter of record, which practically placed the power in the hands of an executive committee of three. That committee was composed of Mr. Shonts and Judge Magoon and myself.

Senator MORGAN. Who was the fourth man that you have just mentioned?

Mr. WALLACE. The other four were the four engineers—that is, Major Harrod, General Ernst, General Hains, and Admiral Endicott. This order provided that the executive committee should meet twice a week on the Isthmus; and it was my understanding of that Executive order that each member of this executive committee had charge of a department in which he was to be practically supreme, and that the chairman had no power over any of us except so far as he had a vote to cast. Now, I hate to repeat conversations, because whenever I do that it brings up a question of veracity.

Senator MORGAN. Oh, well, those questions are up every day here. Mr. Cromwell has made them on you, and I want to see if you can get out of them.

Mr. WALLACE. When the Secretary cabled me the constitution of this Commission, the impression that his cablegram made on my mind was that Mr. Shonts's duty was to be confined to that of purchasing agent in the United States, and such routine work as was necessary to be performed here.

Senator MORGAN. Whose cablegram was that?

Mr. WALLACE. That was the Secretary of War's.

Senator MORGAN. Yes.

Mr. WALLACE. When I came up I found that the Executive order provided for a certain distribution of authority and specified that Mr. Shonts should spend half his time on the Isthmus and half in this country. Just before I went back I was notified by Mr. Shonts that the President, in order to induce him to take this chairmanship of the Commission, had practically promised him absolute dominating authority over us all. Now, those were not his exact words; but he first mentioned it to me in an easy, smiling way, and I did not really know what weight to put on it; and it was not until after I went back to the Isthmus that he commenced to give me instructions which would indicate that he intended to "run the job." Now, Senator—

Senator MORGAN. That is all in regard to the new Commission. I want to get back to the old one.

Senator KITTREDGE. You were about to add something, Mr. Wallace.

Mr. WALLACE. What I was going to add was this: That these personal matters are very unpleasant for me, and I am through with the whole thing now. I am simply a private citizen, like everyone else, and I hope you will not press me on anything of a personal nature any further than you consistently can. I am perfectly willing to come here and answer any questions that you wish and to help you in any way toward getting knowledge on this subject, but I do hope that you will not press me on these personal matters.

Senator TALIAFERRO. You have spoken, Mr. Wallace, of a conversation between Mr. Shonts and yourself.

Mr. WALLACE. Yes.

Senator TALIAFERRO. In which he intimated to you that he had been given a free hand in the management of the work. Did you understand from him that that part of the executive order which required that he should spend half of his time on the Isthmus had been abated or revoked?

Mr. WALLACE. No, I did not understand that. I understood that he practically would be allowed to run things to suit himself.

Senator TALIAFERRO. Including that?

Mr. WALLACE. That particular thing did not occur in connection with it.

Senator TALIAFERRO. He never spent his time there?

Mr. WALLACE. No, sir.

Senator MORGAN. I do not wish Mr. Wallace to bring up any matter at all that would have a tendency to involve him in any personal controversy with any person at all. But what transpired there was between public officials; and all of their dealings with each other of a material sort I think are necessary to be known by the committee, in order that we may know what recommendations to make to the Senate as to the future conduct of this canal.

Mr. WALLACE. I will answer your questions, of course, freely, Mr. Senator. The only thing is that I put myself on your mercy.

Senator MORGAN. Can you state any reason known to you, or any reason urged by superior authority or by any of the Commissioners, why the old Commission was removed, beyond the one that you have stated—that it was too large?

Mr. WALLACE. I do not know of any. Of course, there was all sorts of gossip going around in those days, but the impression seemed to be that the work was not effectively carried out because there were so many men on the Commission.

Senator MORGAN. I notice from the proceedings of that Commission which are recorded here that at every meeting they were all present, except while Mr. Barclay Parsons was excused because of some engagement he had in London, which had been provided for before his appointment; and they worked all through the summer there, the yellow-fever months, and all that sort of thing, day after day. They seem, from the minutes which I hold in my hand, to have done a vast amount of work, at least in the organization of the government of the Panama Zone, and providing for the future successful operations of the engineering and the supply departments, the labor department, the pay department, and all of the other departments, particularly the medical department. These records show a vast amount of work, and, as far as I have gone into the matter, very clear and proper work.

Do you recollect that any order or vote or resolution in regard to any matter contained in these proceedings here was ever revoked by the President?

Mr. WALLACE. I never heard of any; no, sir; and I never heard any criticism on the ability or on the singleness of purpose of any member of that Commission, individually.

Senator MORGAN. Or their industry?

Mr. WALLACE. Or their industry.

Senator MORGAN. Or their staying at their posts and working under unpleasant conditions—unpleasant physical conditions, I mean?

Mr. WALLACE. I never heard of any criticism of that kind; no, sir.

Senator MORGAN. Every one of these orders and reports was submitted to the Secretary of War?

Mr. WALLACE. I do not know as to that. I presume they were, because they were official.

Senator MORGAN. That was required to be done?

Mr. WALLACE. Yes.

Senator MORGAN. This book shows that they were.

Mr. WALLACE. I have no knowledge of that. I was on the Isthmus and they were here, of course.

Senator MORGAN. The first Isthmian Canal Commission (the Walker commission of construction I will call it; there had been a previous Walker commission, but that was one of exploration, and then after we bought the property the commission of construction was appointed) entered upon its duties with nobody present of the commissioners except General Davis, who was the governor of the Canal Zone. He was the only man that was there at first, and then he was soon joined by Mr. Hecker, and others came in afterwards.

Prior to Davis taking hold there as governor and undertaking to establish a government and to get the United States in possession, to accomplish or to begin to accomplish its great task of digging this canal, the reports inform us that no laws prevailed there except the laws of Colombia; that the Panama Canal Company and the railroad company, which were separate organizations, had no right to pass any police regulation or any law or resolution of a governing character, but they were subordinate entirely to the laws of Colombia, and some of the laws of the State of Panama, which was then a State of the Republic of Colombia, and that that system had to be entirely abandoned and a new system substituted for it.

In the situation in which that work was at the time Davis took hold of it as governor, was it not a really herculean task to frame all of these statutes, to make all of these provisions for the inaugurating of any kind of work there, and for getting labor and for getting material, and for cleaning up the debris of the Panama Canal Company? Was it not a very heavy task?

Mr. WALLACE. Yes, it was; and, personally, I have never thought that the Walker commission received anything like the recognition that it should for the service it rendered, particularly General Davis.

Senator MORGAN. Yes. Now, during the operations of that Commission were you aware of any general public complaint as to the work that they were conducting there—of the manner of their conducting it or the diligence and skill and wisdom with which they projected and conducted the work there—on the Isthmus in trying to inaugurate a system of government and a system of labor?

Mr. WALLACE. I never heard any criticism on it. The only criticism was something that was due to an impatient desire, of course, upon the part of everyone to see things move a little faster.

Senator MORGAN. To "make the dirt fly?"

Mr. WALLACE. To "make the dirt fly." Of course my criticism was not directed so much at the Commission as it was at the method. I could not get any material, and I could not get anything furnished for me—I mean in the way that I thought I ought to have it; but that was not due to any want of effort upon the part of the individual members of the Commission.

Senator MORGAN. They did all that they could?

Mr. WALLACE. They seemingly did all that they could.

Senator MORGAN. And they stayed there and did their work?

Mr. WALLACE. Yes, sir; that is, they were down there for about—

Senator MORGAN. And they were all able men?

Mr. WALLACE. They were all able men.

Senator MORGAN. And devoted to duty?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Can you give the committee an idea of the situation of that canal at the time this property and this Zone were turned over to the possession of the United States—the situation in which the French left the canal?

Mr. WALLACE. As far as the situation was concerned, it was simply that it was a jungle.

Senator MORGAN. Chaos.

Mr. WALLACE. Just simply chaos from one end of the Isthmus to the other, and grown up with a jungle, except the small amount of work on which four or five hundred men were employed at Culebra, and they were doing all their work there by hand.

Senator MORGAN. They did not even have any of these little French scoops or shovels?

Mr. WALLACE. No; they were doing their work entirely by hand.

Senator MORGAN. Entirely by hand?

Mr. WALLACE. Yes; hand drilling and everything else.

Senator MORGAN. How many hundred years would it have taken them to have completed that canal with the force that they had on hand then, working by hand?

Mr. WALLACE. Oh, I suppose from two to three hundred.

Senator MORGAN. From two to three hundred years?

Mr. WALLACE. Yes, sir.

Senator MORGAN. I do not suppose that you consider that the work that they were doing there was being done with an earnest effort to complete the canal, or with an expectation that it could be completed at that rate of work?

Mr. WALLACE. Oh, no; that was utterly impossible. It seemed more like a case of their simply spending the least possible amount of money in order to retain possession of the franchise. That was the way that it impressed me.

Senator MORGAN. They were working just enough to keep Colombia from forfeiting the franchise?

Mr. WALLACE. That is the way it impressed me; yes.

Senator MORGAN. As to the machinery that you found there in the jungle and about in different places along the railroad track and along the canal work, what condition was that in?

Mr. WALLACE. The machinery that had not been issued to contractors, but was housed, was in first-rate condition. The machinery that had been issued to contractors and had been put in use was scattered in a heterogeneous mass all over that canal, and was out in the jungle, and was just as they had left it at the time they went into liquidation.

Senator MORGAN. There is a good deal of it that has not been discovered yet, is there not?

Mr. WALLACE. I presume there is.

Senator MORGAN. Is it not a fact that when they want to get certain descriptions of machinery down there that they are not immediately supplied with, they go out into the jungle and hunt it up?

Mr. WALLACE. Oh, that is frequently the case; yes, sir.

Senator MORGAN. That was frequently the case?

Mr. WALLACE. Yes.

Senator MORGAN. Like a man hunting a venison down with a pack of dogs?

Mr. WALLACE. Yes; they had a complete record of everything they had on hand.

Senator MORGAN. They had it on paper?

Mr. WALLACE. It was all on paper; yes.

Senator MORGAN. But it was out in the woods?

Mr. WALLACE. It was out in the woods. But the material in their storehouses was admirably arranged and was well taken care of.

Senator MORGAN. The part of it that was under the control of the railway was pretty well managed, was it not?

Mr. WALLACE. Yes. While I think the railroad's policy was radically wrong, the carrying out of that policy, as far as the maintenance and operation of the railroad on the Isthmus was concerned, was admirably done. That is, Colonel Shaler, the general superintendent, and Mr. Prescott, the assistant superintendent, and the staff under them did the very best they could with the facilities they had at hand.

Senator MORGAN. Now, Mr. Wallace, at the time this first commission of construction, the Walker commission, took charge there, was it possible to prepare that commission for proper work such as the American Government expects to do inside of a period of two years?

Mr. WALLACE. In my first conference with the commission after I was appointed chief engineer I asked for two years in which to make preparatory arrangements; and I thought then, and I think now, that two years was little enough.

Senator MORGAN. It has proved to be too little, has it not?

Mr. WALLACE. Yes.

Senator MORGAN. Very much too little?

Mr. WALLACE. Yes; little enough to get things together and build up an organization and get a good start at the real work in a real way.

Senator MORGAN. Under both Davis and Magoon, and also under Shonts, have not the officers of the Government who have been on the Isthmus, practically engaged in the work there, employed all possible diligence, in your opinion, to clean up this mass of waste and chaparral, or whatever it is? Have not these officers, all that have been there, dutifully employed themselves in strenuous efforts to accomplish this task of cleaning up?

Mr. WALLACE. I think they have; but, of course, since I left there the only means I have of judging is what I have seen in the newspapers, and what I have seen in the testimony before this committee.

Senator MORGAN. Leaving out of view, now, all the reports, was it your observation, as long as you stayed on the Isthmus there, that both the Commissions, the first one and the second one, did, through the men who remained on the Isthmus and devoted themselves to work, all that could practically be done in cleaning up and making preparation for the real work of digging the canal?

Mr. WALLACE. I think so; yes.

Senator MORGAN. You know of no criticism upon their operations that would show any suspicion of delinquency on the part of any of them?

Mr. WALLACE. From such knowledge as I have I do not know of any; no.

Senator MORGAN. When the new organization took place, and its labors were divided up in the manner in which you have indicated, and which is shown upon these records, was there any additional spur put into the work greater than had been employed before under the first

Walker Commission? Was there any greater success in the operations after the new Commission got in than there was before, during the time that you remained there?

Mr. WALLACE. Well, the furnishing of materials was slightly expedited, and I looked upon the new organization as an improvement of the old organization.

Senator MORGAN. As an organization?

Mr. WALLACE. As an organization.

Senator MORGAN. I am speaking of the execution of it.

Mr. WALLACE. The time was so short and was so interlaced with what had been done before that it would be a very difficult matter to tell.

Senator MORGAN. Did you have to undo anything, or anything of importance, that the first Commission had done?

Mr. WALLACE. Nothing of any importance. The work was in expediting the getting of material down there and things of that sort.

Senator MORGAN. Yes. Did that first Commission do any work or have any work done there that had to be thrown away?

Mr. WALLACE. Not an item that I know of.

Senator MORGAN. Not an item that you know of?

Mr. WALLACE. No, sir.

Senator MORGAN. There is some story going around that in your work there as chief engineer you had fixed your dumps at places where they would hereafter have to be removed. Is that true?

Mr. WALLACE. That is not true, and Mr. Stevens, the present chief engineer, in his examination went on record as saying that it is not true.

Senator MORGAN. So that no work has been done in vain there, so far as you know?

Mr. WALLACE. Not a dollar's worth, as far as I know.

Senator MORGAN. And, so far as you know, an observance of duty and diligence and earnest interest in the work have been manifested and exhibited by all who were concerned in that work in the higher ranks of office?

Mr. WALLACE. I think so.

Senator MORGAN. In the new organization there appear here to have been a great many appointments made. They were made by the heads of these departments into which the work was divided. There was one grand division in the separation into departments; one consisted of four engineers and the other consisted of three men, who formed an executive committee. The four engineers appear to have had charge of all the subjects connected with engineering proper and the conduct of the engineering work. Is that right?

Mr. WALLACE. No, sir; they were not supposed to have any direction, up to the time that I left, over the engineering work on the Isthmus.

Senator MORGAN. Who had it?

Mr. WALLACE. That is, I mean except so far as their votes went at the quarterly meetings of the Commission on such questions as might be submitted to them by the executive committee.

Senator MORGAN. By the executive committee?

Mr. WALLACE. By the executive committee; yes, sir.

Senator MORGAN. So that engineering work had first to undergo the approval of the executive committee?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And then that had to undergo the criticism and approval or disapproval of the quarterly meetings of the full board?

Mr. WALLACE. Yes; that is the way I understand it.

Senator MORGAN. During that period and up to the date of and more particularly after the reorganization there was this very long list of appointments to office?

Mr. WALLACE. Yes, sir.

Senator MORGAN. These men that were appointed assembled there on the Isthmus?

Mr. WALLACE. I only know of those in whose appointment I was instrumental.

Senator MORGAN. Yes.

Mr. WALLACE. I do not know anything about anything that has occurred since I left there.

Senator MORGAN. I know; not since you left there, but while you were there, these men were assembling to fill the places given them under each of these chiefs of departments?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Corresponding in some sense to the heads of departments here in the Government?

Mr. WALLACE. Yes, sir.

Senator MORGAN. The appointments were made by the heads of the departments?

Mr. WALLACE. Yes, sir.

Senator MORGAN. But the Commission, as a body, had the right to overrule and strike out any that they did not approve of. They ratified and confirmed them, every one of them, by resolution?

Mr. WALLACE. Yes, sir.

Senator MORGAN. With perhaps one or two exceptions. Did not that produce a very sudden and great influx of gold men upon the Isthmus?

Mr. WALLACE. The increase in the gold men, I think, was more rapid after the 1st of April than it was before. I have not at hand the list, but there are records that show exactly how many came down each month.

Senator MORGAN. And they came down there without any preparation of an important character having been made for their accommodation in the way of houses?

Mr. WALLACE. No, sir. I never saw any white men that came to the Isthmus at the time I was there that were not just as well or better provided for than they would have been if they had gone out on a piece of railroad work in the United States. Of course this was true: There were not buildings or accommodations enough to take care of the men the way the men would like to be taken care of that intended to bring their families and stay ten years on a piece of work—that is very true; but the men that came down there were comfortably housed, and while they had to put up with some inconvenience, as I said before, the inconveniences were not as great as they would have had to put up with if they had gone out into Iowa or Illinois on the construction of a new railroad line in this country.

Senator MORGAN. Those accommodations had been provided for them by the repair of houses and the building of houses by the first Walker commission?

Mr. WALLACE. Yes, sir.

Senator MORGAN. They had made all that preliminary preparation?

Mr. WALLACE. Yes, sir; and we had built two hotels. I do not think any large hotels have been built since. I have not heard of any. But at the time I left there the large hotel at Corozal and the large hotel at Culebra were in actual service.

Senator MORGAN. Yes.

Mr. WALLACE. And other buildings were being put up just as fast as the material could arrive on the Isthmus to put them up. My recollection is that we had a force of about 1,700 or 1,800 men whose sole duty was the repair and erection of houses for the rest of the men to live in.

Senator MORGAN. There was also a very rapid influx of labor into the Zone?

Mr. WALLACE. It has been increasing right along. From the 1st of July, 1904, until the 1st of July, 1905, my recollection is that between 9,000 and 10,000 men arrived on the Isthmus.

Senator MORGAN. Silver men?

Mr. WALLACE. Silver and gold, altogether.

Senator MORGAN. So that influx was comparatively very rapid?

Mr. WALLACE. Some of them returned. I do not remember how many were actually on the rolls.

Senator MORGAN. Of course, providing food and quarters for those men was an embarrassing and difficult proposition?

Mr. WALLACE. It was.

Senator MORGAN. In the meantime, what interest had the first Walker commission bestowed upon sanitation? Had they been very active in trying to provide for the sanitation of the Isthmus?

Mr. WALLACE. The sanitation of the Isthmus was put under the control of Colonel Gorgas, and that went on, I understand, in a continuous manner from the time I went down there in June, 1904—we went down on the same boat together—up to the time that I left there. He was going right along with his organization regularly, and he had an organization of his own engaged in draining the swamps and in various sanitary operations.

Senator MORGAN. Had the first Walker commission participated in the preparations necessary for the sanitation of the Isthmus?

Mr. WALLACE. That was the source of authority—the first Walker Commission—up to the 1st of April.

Senator MORGAN. That was the first great point to be attained?

Mr. WALLACE. Yes, sir.

Senator MORGAN. To produce a reasonable degree of health in the Isthmus?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Who was present besides the Commission in the planning of this reorganization?

Mr. WALLACE. The railroad organization?

Senator MORGAN. I mean the reorganization of the railroad and the canal.

Mr. WALLACE. I only recollect one conversation in regard to the organization of the railroad, and the Secretary and Mr. Shonts and Mr. Magoon and myself had that conference.

Senator MORGAN. That was after you were made a Commissioner?

Mr. WALLACE. That was after I was made a Commissioner.

Senator MORGAN. And before you returned to the Isthmus?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Who was assisting in arranging this new organization?

Mr. WALLACE. I always understood that the whole scheme, the organization, was discussed by Mr. Cromwell and the Secretary and was practically worked out by Mr. Cromwell, but that is simply hearsay. I was not here at that time.

Senator MORGAN. Was he engaged there as an employed counsel, or employed agent to do that work, or was he doing it pro bono publico?

Mr. WALLACE. I do not know. His only official position that I knew of was his position as general counsel for the Panama Railroad, and he wrote up the resolutions and attended all the meetings of the executive committee of the railroad and board of directors of the railroad, and seemed to direct its affairs entirely, as far as the records were concerned.

Senator TALIAFERRO. Was he not a railroad director at that time?

Mr. WALLACE. Yes, sir. He was a member of the new board of the Panama Railroad.

Senator MORGAN. During that time of the reorganization, or before that time or after that time, as long as communications were open between you and Mr. Cromwell, did you have any knowledge of a claim that he presented as the counsel of the New Panama Canal Company against the Government of the United States amounting to more than two millions of dollars?

Mr. WALLACE. Yes, sir.

Senator MORGAN. A claim of two million and two or three hundred thousand dollars for the work that had been done by the French company after their first proposition to sell to the United States and up to the time of the turning over? Did you hear about it?

Mr. WALLACE. Yes, sir; I was present when he presented that to the Walker Commission to pass on as to the facts contained in it, and that matter is a record of the second Walker Commission. It is spread on their records.

Senator MORGAN. Yes; I have it all here. That claim was first brought before the first Walker Commission?

Mr. WALLACE. The first thing I knew about it was when I was present at a meeting of that Commission, when Mr. Cromwell and another lawyer and Mr. Choron, the chief engineer of the New Panama Canal Company, and an interpreter came before the Walker Commission, in June, 1904, and stated that the President had been asked to arbitrate that claim, and that the question of law had been referred to the Attorney-General and the question of fact had been referred to the Isthmian Canal Commission, and Mr. Cromwell and these men were here to present these facts for the Isthmian Canal Commission to pass upon as to their reliability—I mean as to what were facts and what were not facts—and ready to offer any explanation of their figures that they desired to ask the gentlemen that were present, naming his colleagues.

Senator MORGAN. Did the Commission have any order from the President of the United States that they should perform the duty as arbitrators for settling the fact in regard to the claim?

Mr. WALLACE. They were not to act as arbitrators. Mr. Cromwell stated that the President was to act as an arbitrator and that the Com-

mission was to pass on the facts, the Attorney-General on the law, and then the President would take the question up and pass on the equity. That was what I understood was Mr. Cromwell's statement that he verbally made before the Isthmian Canal Commission when he presented these papers to them.

Senator MORGAN. You were then chief engineer, but you were not a Commissioner?

Mr. WALLACE. I was not a Commissioner, but I just happened to be present at the interview.

Senator MORGAN. Had Cromwell talked to you about it?

Mr. WALLACE. No, sir.

Senator MORGAN. He had never explained it to you?

Mr. WALLACE. No, sir. That was the first time I ever met him.

Senator MORGAN. What was this other lawyer's name that was there?

Mr. WALLACE. I do not remember.

Senator MORGAN. Was he an American or a Spaniard?

Mr. WALLACE. He was an American.

Senator MORGAN. Was he named Curtis?

Mr. WALLACE. I think that was his name. He was a square-jawed man, a little younger than Mr. Cromwell.

Senator MORGAN. Was he a tall, slender man?

Mr. WALLACE. I do not remember his description. He was sitting at the table when I saw him.

Senator MORGAN. Was Mr. Farnham there at that time?

Mr. WALLACE. He was not at the meeting.

Senator MORGAN. He was on the Isthmus?

Mr. WALLACE. No, sir; I do not know where he was. He was not at the meeting.

Senator MORGAN. Did Mr. Cromwell lay before that Commission any orders of the President or directions of the President that they should find the facts in regard to this matter?

Mr. WALLACE. I do not know.

Senator MORGAN. You saw no such paper?

Mr. WALLACE. I saw no such paper.

Senator MORGAN. And no such paper, within your knowledge, has ever been put upon record?

Mr. WALLACE. No, sir.

Senator MORGAN. It was Cromwell's statement?

Mr. WALLACE. That is as I recollect it. There might have been a letter.

Senator MORGAN. Of course. We want your recollection. We know it is honest, and we just want that. So he appeared before that Commission and informed them that the President had authorized them to find the facts?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And that the Attorney-General was to ascertain the law and the President was to determine the equity of the claim?

Mr. WALLACE. Yes, sir; that is the way I understand it.

Senator MORGAN. Was the claim earnestly pressed?

Mr. WALLACE. Well, rather.

Senator MORGAN. Did Mr. Cromwell make a statement about it?

Mr. WALLACE. Yes, sir; he made quite an extended statement in regard to it, and he seemed to be very anxious that it should be given attention in the near future.

Senator MORGAN. In what way did the old Commission receive that proposition?

Mr. WALLACE. I would have to go behind the motives in their bosoms to tell you that. They did not seem to be very enthusiastic over it.

Senator MORGAN. Did they seem opposed to it or to question it?

Mr. WALLACE. That was the impression it created on me, listening to the presentation and hearing their discussion of it.

Senator MORGAN. Did they question it severely, like a judge on the bench?

Mr. WALLACE. There was a great deal of comment made, but the matter was explained to them that it was not for them to criticise its equity; that their function was to determine whether this money had been spent or not, and that that was all that they were to do, although the impression that was created on my mind was that they were, most of them, disposed to criticise the equity of the claim.

Senator MORGAN. Was the claim afterwards presented, within your knowledge, to the old Commission?

Mr. WALLACE. To the new Commission?

Senator MORGAN. The old Commission, the first Walker Commission.

Mr. WALLACE. This was the construction Walker Commission that I am talking about.

Senator MORGAN. I know. Was it afterwards, within your knowledge, presented to that Commission?

Mr. WALLACE. Again?

Senator MORGAN. Yes.

Mr. WALLACE. I never heard of it after that.

Senator MORGAN. Until you got on the new Commission. You heard of it then, did you not?

Mr. WALLACE. I never heard of it then.

Senator MORGAN. The records show that it was very much discussed by the new Commission.

Mr. WALLACE. Yes.

Senator MORGAN. That claim is still pending.

Mr. WALLACE. I do not know anything about it. That is, except since that date.

Senator MORGAN. And it was after that that Mr. Cromwell took a very decided interest in your being made a commissioner?

Mr. WALLACE. Well, I do not know that he did.

Senator MORGAN. The correspondence that he had presented to this committee, a letter written by you to him, and also an extract from a letter of a confidential character that Mr. Shonts submitted to him would show that your relations were very confidential, so much so that one of your letters Mr. Cromwell characterized as being fulsome. You have read all of his testimony?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And he spoke of being ashamed to present it on that account?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Taking his description of his relations to you as he gave them in his testimony, all of which you have read, and taking

your knowledge of your relations to him, did he give a fair account of your relations?

Mr. WALLACE. Not from my standpoint.

Senator MORGAN. Your standpoint is the one we want. You are the only man in the world that knows about it.

Mr. WALLACE. My personal relations with Mr. Cromwell were very friendly.

Senator MORGAN. Yes.

Mr. WALLACE. But I would have to go into quite a long explanation as to why I wrote that letter that would involve a great many things, and that is one of the reasons why I did not want to be asked about it.

Senator MORGAN. I have only asked you what he has put upon the record. I have not gone into anything else, and you are entirely at liberty to state or not to state anything beyond that by way of explanation as you may choose.

Mr. WALLACE. The last night before I sailed I was a guest at Mr. Cromwell's house. There were quite a number there—the members of the Commission were there as guests—and Mr. Cromwell pressed on me some of his views, and he did it in a way that I took very strong exceptions to, not due to the nature of what he said, because the ideas that he gave me were perfectly proper in themselves, but I took it as an interference with my conduct of my business, and we had rather an animated discussion over it; that is, so warm on my part and I felt so keenly over it that I felt as if I had rather exceeded the bounds of propriety.

Senator MORGAN. In your reply to him?

Mr. WALLACE. In my reply to him; yes. And I did not want to incur his ill will, particularly at that time. I wanted to keep on good terms with everybody, as far as I consistently could. So I made up my mind that I ought to in some way try to smooth this over. So, just as soon as I got back to the Isthmus again, where I had time enough to write, I wrote him that letter, in order to make things just as smooth between us as I possibly could.

Senator MORGAN. In that conversation at his house before you sailed—it was the night before you sailed, was it?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And Mrs. Wallace was with you?

Mr. WALLACE. No, sir.

Senator MORGAN. Did she not go to the Isthmus with you, then?

Mr. WALLACE. Yes; but there were no ladies at this dinner except Mrs. Cromwell.

Senator MORGAN. On that night, if I understand you correctly, Mr. Cromwell undertook to give you advice that you interpreted even as instructions in regard to your business?

Mr. WALLACE. Yes, sir.

Senator MORGAN. As chief engineer of the Commission?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And you resented it?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And you did it in such words as to lead you to think afterwards that perhaps you had abused his hospitality?

Mr. WALLACE. Yes, sir.

Senator MORGAN. And when you got to the Isthmus you wrote that letter that he styled fulsome?

Mr. WALLACE. Yes, sir.

Senator MORGAN. For the purpose of preventing him from considering that you had made any personal attack upon him, and to let him understand that you wished to "let bygones be bygones" between you, as I understand it? Is that the fact?

Mr. WALLACE. Yes, sir.

Senator MORGAN. That is the situation?

Mr. WALLACE. Yes, sir.

Senator MORGAN. So that he never mentioned to you, after you were a Commissioner, this \$2,250,000 claim?

Mr. WALLACE. No, sir.

Senator MORGAN. Do you know of his ever having mentioned it to anybody else?

Mr. WALLACE. No, sir.

Senator MORGAN. You have heard no Commissioner say that he had presented it to them?

Mr. WALLACE. No, sir. I might have heard that, but I have no recollection of it.

Senator MORGAN. He is still pressing that claim, so far as you know?

Mr. WALLACE. I have absolutely no knowledge on the subject.

Senator MORGAN. Do you know of any facts, Mr. Wallace, that you think indicate an interference on the part of Mr. Cromwell for the purpose of getting rid of the old Commission or any members of the old Commission?

Mr. WALLACE. I was on the Isthmus during that time.

Senator MORGAN. Yes.

Mr. WALLACE. And anything of that kind that would have been done, of course, would have been confined to the United States; and I had no knowledge of his doing anything of that kind, although I have an impression that some of the Commission themselves thought there might be something in that.

Senator MORGAN. That was it. Some of the Commissioners at the time, in trying to account for the fact of their removal, associated his efforts with the fact of their removal?

Mr. WALLACE. That is the impression I received. I am not able to say, or to give you positive details of how I acquired it; but that was the impression that I had.

Senator MORGAN. You would not have known anything about it unless it had been discussed in your presence, would you?

Mr. WALLACE. I presume not.

Senator MORGAN. Do you recall what were the subjects that were presented to you in an unpleasant way at that dinner the night before you left, by Mr. Cromwell?

Mr. WALLACE. I do not remember exactly. I think it had something to do with my organization. I think he was rather impressing on me the employment of more high-priced men than I had.

Senator MORGAN. Higher priced men?

Mr. WALLACE. Yes.

Senator MORGAN. Did he name anybody?

Mr. WALLACE. He did not give any special names of anyone. It did not get that far along.

Senator MORGAN. You did not understand to whom he referred?

Mr. WALLACE. No; he was particularly desirous that I should get a deputy chief engineer that would be able to handle that work in case anything should happen to me.

Senator MORGAN. He insisted on higher prices?

Mr. WALLACE. Well, I do not remember that the term "high-priced" was used, but it was high-class men that he was urging, and the securing of what we call a duplicate organization. I already, at that time, had Mr. Dauchy, who had been chief engineer of the Rock Island system, who I thought was a very capable man, and I had employed Mr. Maltby, who was a very capable man, and I had been hunting all over the United States for a first-class man to fill a position next to me.

I did not believe it was necessary to explain to Mr. Cromwell what my ideas were, or what I had been doing, because I did not consider it any of his business. I was actually working along the lines that he had suggested; but the impression that he made on me was that he thought I was not competent to think of doing anything in this line unless he suggested it; and that it was his idea that I had neglected that part of the work, and that I should be punched up about it, and that that was what he was trying to do.

Senator MORGAN. Did he undertake to advise you about any other matter connected with your business?

Mr. WALLACE. That thing we discussed at some length, and the conversation was quite long. I do not recollect the details of it now.

Senator MORGAN. But it was a general admonition or advice to you in regard to how you should conduct your business?

Mr. WALLACE. It was principally in the line of getting more men in the higher positions.

Senator MORGAN. Did he say anything about having been instrumental in having your appointment as Commissioner made?

Mr. WALLACE. I do not remember whether he did at that time or not.

Senator MORGAN. Did he at any time?

Mr. WALLACE. Well, my impression is that he did, but I could not—

Senator MORGAN. He claimed the credit to himself of having had you appointed?

Mr. WALLACE. My impression is that he did, but I do not remember exactly.

Senator MORGAN. Was that offensive to you?

Mr. WALLACE. Yes; in a way it was; but those were the things that I generally took with a smile, that part of it. Mr. Cromwell and I, from the very first, to use a slang expression, were always rather disposed to "jolly" each other.

Senator MORGAN. You have looked very carefully over his testimony as he gave it here?

Mr. WALLACE. I have read it; yes.

Senator MORGAN. You have read and studied, I suppose, the account that he gives of what transpired at the time that Mr. Taft came up from Washington to hear your statement as to your purpose of resigning as chief engineer and also as Commissioner; you have seen all of his statements?

Mr. WALLACE. Yes, sir.

Senator MORGAN. Have you any change to make in the statement that you made before this committee the first time in regard to those matters?

Mr. WALLACE. I have no change to make in the statements that I made before this committee originally, and I want to say right now that while Mr. Cromwell may have misunderstood my language, I tried my very best to impress upon him that that interview should be a personal and private interview; and he even went to the extent of telling me that if I thought the Manhattan Hotel was not private enough he would arrange for it at his own house and let the Secretary and me be there alone. Mr. Cromwell, to my mind, thoroughly understood that he was not to be at that interview, and he started to leave the room as my son did, who accompanied me into the room, and to leave the Secretary and me there alone, when the Secretary called him back and told him that he wanted him to remain through the interview, and Mr. Cromwell sat down.

Senator MORGAN. Do you know of any occasion or interest for the secretary to have a witness present at that conversation with you?

Mr. WALLACE. I know of no reason why.

Senator MORGAN. You had no suspicion that he desired to have some one to verify what you said?

Mr. WALLACE. No, sir; not until that moment.

Senator MORGAN. And you regarded Mr. Cromwell, then, as an intruder?

Mr. WALLACE. I most certainly did.

Senator MORGAN. I think I will not ask any more questions.

Senator KITTREDGE. There is one more question that I wish to ask regarding the type of canal: As I understand your statement regarding the sea-level proposition, Mr. Wallace, there are connected with it no unusual, untried, or doubtful problems?

Mr. WALLACE. There are none whatever, Mr. Senator. It is simply a plain case of digging a ditch of large dimensions. While that ditch is larger than any ditch we have ever dug before in this world, there are no elements of uncertainty about it except those that go with a job a little larger than what we have done before. The same principles are involved and the same methods can be used.

The amount of excavation to be made there is so great that it permits a great many economies that would not be possible in a smaller piece of work. For instance, a cent a yard on that work will pay for all the steam shovels you have got to buy for it. Six or seven cents a yard will pay for all your engines and cars and almost the entire plant that you have to buy new. That is, the fact that the work is so large and that it will extend over about the life of the machinery that is put into it makes it a very economical proposition from the standpoint of the installation of a plant for it.

The CHAIRMAN. I think, in your previous testimony, you stated that your belief was that all the work, practically, should be done at the Isthmus, and not in Washington. Am I correct in that?

Mr. WALLACE. Yes, sir.

The CHAIRMAN. Do you think that there should be a very small force here, or a large force here?

Mr. WALLACE. I do not believe that you need any more force in Washington than may be necessary to keep such records as the Presi-

dent and his Cabinet and Congress may desire for their record, and the Treasury Department.

The CHAIRMAN. You think, perhaps, then, that the force that is here in the city now should be transferred to the Isthmus? Is that your idea?

Mr. WALLACE. All of it that is necessary for the work. In other words, that the organization down there should be as complete and as separate from the United States as your government in the Philippines—more so, if possible. In other words, the nearer you can handle that work the way a large contractor would handle it the more efficient the results will be. What we do need is such supervision over that construction as that you may get a canal there so wide and so deep located along a certain line as soon as possible and have the work done as well as possible.

The CHAIRMAN. It would be necessary for that supervision to be there on the Isthmus and not here?

Mr. WALLACE. Yes; that supervision should be on the Isthmus, and should not be in Washington.

Senator KITTREDGE. Suppose that Congress should decide to construct a sea-level canal from the Atlantic to Obispo, and from the Pacific to Miraflores, with a width of 300 feet, would its construction materially extend the time of doing the work?

Mr. WALLACE. No, sir; it would increase the cost, but it would not extend the time, because that additional work would not last longer than it would take to cut through the continental divide. It could all be done inside of the period that you are taking out your central excavation.

The CHAIRMAN. I believe there are no other Senators that desire to ask you any questions, Mr. Wallace.

Mr. WALLACE. There are one or two suggestions that I would like to volunteer, if you will permit me to do so.

The CHAIRMAN. We shall be very glad to hear them, Mr. Wallace.

Mr. WALLACE. One is with regard to the rate on the Panama Railroad.

In the testimony of one of the witnesses—I think the president of the Panama Railroad—he said that the cost of handling freight across the Isthmus was \$3.10 a ton. That is 47 to 50 miles, and that is over 6 cents a ton a mile. I want to say to you gentlemen that that is the strongest argument that could be made before you for the proper equipment of the Panama Railroad with modern appliances. One-tenth of that amount—that is, six-tenths of a cent a ton a mile—represents the gross revenue of a great many of the railroads in the United States, out of which they have to pay their maintenance, their fixed charges, and everything else; and the fact that it costs \$3.10, or 6 cents a ton a mile, to handle freight across the Isthmus simply shows that that railroad is from twenty-five to forty years behind the times.

The engines that were there when I was there, when they were double headed, only hauled 171 tons over that divide at Culebra, a grade of about 1½ per cent. The new engines which we bought about that time—24 of them—were drawn up on specifications which should enable two of them to handle 1,000 tons over that hill. That thousand tons could be handled for the same cost, as far as transportation is concerned, as the 171 tons could be before, except that they would take a little additional coal; but they would not take any more supervision,

and there would be no other additional expense connected with it. In other words, if you make this 171 tons 200 tons, the expense of transportation on the Isthmus up to the time those new engines were put into service would be just about one-fifth of what it would be if it was equipped with modern cars and modern engines.

Senator TALIAFERRO. You mean five times as much, do you not?

Mr. WALLACE. Yes, sir. If you provide proper facilities for loading and the proper wharves so that you can handle that business properly you can make money at \$2 a ton flat. It is true that when I say \$2 a ton flat, without classification, I do not mean that the freight that passes through the canal will not be classified, because all through bills of freight will be classified in accordance with the custom of the steamship line or the route over which it sails. But what I mean to say is that you get as near as you can with a railroad a condition which will be similar to what you will get when the canal is built.

When the canal is built you will charge on the tonnage of the vessels; that is, it will be a flat rate as far as the stuff in any one vessel is concerned. The nearer the vessel is full the lower the rate will be per ton for the stuff that is actually carried in the vessel, as your canal rate will be either the Danube measurement or the English, or, say, net registered tonnage, or something like that; but it will have the effect of a flat rate. Any flat rate you put on that business over the railroad—the lower the better—will have a proportionate effect on the rates through this canal, although those through rates may in themselves be classified rates. But so far as that part of the transit across the Isthmus is concerned you are approaching the same condition of affairs, in a measure, that you will have when you get your canal completed. That is simply a point I wanted to clear up.

Just before I go, there is another thing that I would like to say to you, and that is this: That I do not think that you can overappreciate the importance of the effect of protecting our future trade by heading off the possible development of that route by way of Tehuantepec. It goes without saying that it is much easier to hold a line of traffic than it is to get it away from somebody else after they get it once. I do not think that there are very many people that appreciate what the Tehuantepec route means if they get it established once. A low rate now at Panama and the demonstration to the shipping world that you can handle their stuff there, and handle it promptly and satisfactorily, is going to keep the business that you have got and is going to increase it very rapidly.

Another point: Of course it goes without saying that some time will elapse after the canal is completed before you will get enough revenue out of the tolls to pay your interest and to pay your expense of maintenance and operation. But the increase in that business will be gradual year by year, and every year you can advance the consummation of that condition you lose that much less money. If you commence to carry that business there now, and develop your railroad to its limit in the first place, and make the rate low, and it takes ten years to build the canal, the time when the canal will pay for itself will be just ten years nearer to you. In other words, you can afford to operate the Panama Railroad at a loss of one or two or three or even five hundred thousand or a million dollars a year in order to build up that business, rather than to wait until the canal is done and then attempt to do it by the canal itself, after you have absolutely ruined that route

as a transportation line, because then your loss may be five or six or seven or eight or ten millions of dollars a year if you have not got the business for your canal.

The CHAIRMAN. Your idea is to hold on to the present business and get what you can?

Mr. WALLACE; Yes, sir; and to get all that you can, just the same as if I was operating it for a private corporation.

The distance from New York to Hongkong by way of the Tehauntepec Railway is 1,351 miles nearer than by the way of Panama. Freights are worth on an average of \$1 a ton for a thousand miles. That means that the Tehauntepec route would be \$1.35 plus the rate over the railroad which, say, might be \$2 or \$3 a ton—granting it is about \$3 now—which would make \$4.35 a ton. Any less sum than that could be charged by the Tehauntepec Railroad, and make money out of it, and also save about five days in time.

The distance from New York to San Francisco by that line is about 1,200 miles shorter than by way of Panama. There you have \$1.20, plus the toll across the Isthmus of \$3, or whatever it will be, and the saving in time of about four or five days. That holds good all through here—I mean in varying proportions—but they have an advantage. That is partly, of course, compensated by the fact that they have 175 miles to haul that stuff, and it will cost them the same to handle their stuff on the wharves that it does at Panama and Colon, and it will cost them about three times as much to handle it over the railroad. And there is a reverse advantage to us in that fact, which we can overcome by a low flat charge at Panama now, if we fix it up, and we can keep that business for a less loss than we can ever get it back again.

I have some data here about these rates that I would be perfectly willing to leave for your record.

The CHAIRMAN. We should be glad to have them.

Mr. WALLACE. Also I have a short paper here that shows the various ways of working out canal dues, etc., and some other notes that I had as a memorandum. I shall leave them with you, as they express some of the things that I have said in better language than I have expressed them in my verbal examination.

The CHAIRMAN. We shall be glad to have those put in the record. We appreciate your coming, Mr. Wallace, and will excuse you now so that you may catch your train if you desire.

(The committee thereupon adjourned until to-morrow, March 21, 1906, at 2.30 o'clock p. m.)

(The following papers, submitted by Mr. Wallace, are printed by order of the committee.)

THE GATUN DAM.

There is no reason to believe that the weight of the Gatun dam will compress the permeable strata which exists in the Chagres Valley in the gorge 250 feet deep. While mud and ordinary clay compress under weight the witness knows no case where a permeable strata of freely water-bearing material, fully saturated, has ever been cut off by a weight imposed on a surface 250 feet above it, as is the situation at Gatun.

The fact that water now freely flows in some of these bottom stratas at a very great depth below the surface should be a sufficient answer to this question; also the fact that large streams of subterranean water frequently exists, freely flowing in large quantities in stratas of gravel and sand at great depths, in which it is supposed the weight above it would compress it.

In my own experience I have found indurated clay in the bed of the Missouri River, and underneath it I have found loose gravel, bowlders, and sand of a freely water-bearing nature, and this clay has been so hard that it has weighed as high as 120 pounds to the cubic foot; as compared with the indurated clay at Gatun it would be called rock.

As the strains on masonry dams are the subject of more or less mathematical determination, taken in connection with the experience of centuries in their construction, the assurance of their permanency is beyond question.

It is utterly impossible to make a mathematical demonstration as to the permanency of earthen dams, and the fact that a dam of earth in one locality constructed on an alluvial foundation with a freely water-bearing material underneath has stood for a few years is no evidence that an earthen dam situated in another locality on a foundation of this character will stand, as it is utterly impossible to compare the foundation conditions of the two dams, and any opinion on this point is purely a matter of conjecture.

The difference in the character of the foundations of the Gatun dam is such that there is some question as to an unequal settlement of the material of which the dam is composed; and if any part of the material should be compressed as predicted by the report of the Consulting Engineers, cracks would develop which might allow the water to permeate.

BASIS FOR MR. STEARNS'S TESTIMONY.

As I read Mr. Stearns's testimony he bases his main argument in favor of the Gatun dam on an earthen dam recently built under his control in the United States where there is no evidence that exactly the same conditions exist as at Gatun, and which dam has not yet been subject to the pressure or strains which will exist at Gatun, and which dam may properly be considered not as a demonstrated but as an experimental proposition. If the dam mentioned by Mr. Stearns had stood for one hundred years and the character of the material for the same depth was exactly similar to that of the Gatun dam, it might be possible to cite it as an argument in favor of the Gatun dam, but even then it would be of doubtful significance.

SLOPES OF THE GATUN DAM.

The slope at which it is proposed to construct the dam is liable to rapid disintegration from frequent wash on account of the heavy rainfall at that locality unless it is protected in some way.

On account of the heavy rainfall it is a most unfavorable location for the construction of earthen dams, as the material is likely to become supersaturated and be subject to surface washing, sloughing, and disintegration.

LABORATORY TESTS.

All laboratory tests regarding the filtration of water through sand or gravel, to my mind, are utterly valueless in the treatment of a question of this kind, as there can be no reasonable parallel in the conditions. It is not a question of the dam itself holding back this water, but the free flow of water in the impervious strata which is known to exist in these gorges, which it is proposed to leave at this great depth under the foundations of this dam.

THE GATUN LOCKS.

One of the great dangers of locks, particularly when three are placed in flights, is that they require continuous construction of concrete walls for approximately a mile in length and the material must be of such a uniform, homogeneous nature as to prevent unequal settlement of the locks. If the material is different in character the result would be disastrous, and this is immensely intensified by the extreme length of the large masses of concrete which would be necessary in their construction.

TIDAL LOCKS.

The necessity for tidal locks has not been demonstrated, but has simply been agreed to by the Board of Consulting Engineers as a matter of precaution as they have not been able to make any mathematical demonstration of the effect of currents of a free entrance. While I am not prepared to say that at certain stages of the tide it would not be advantageous to have locks, I have not yet been convinced in my own mind of their absolute necessity, and I have yet to see any calculations which demonstrate that they would be.

MAINTENANCE AND OPERATION.

I think the estimates for the maintenance of the sea-level canal are entirely too high. The amount of sediment brought into the canal depends upon the area of the surface washed and the amount of rainfall which finds its way directly into the canal, and this can be taken care of by diversion channels. The mere fact that so many million cubic yards of dirt have been excavated does not of itself increase the amount of sediment. The various benches can be properly treated and the water can be taken out laterally and turned into diversion channels or turned into basins which will take it out of the canal entirely.

PANAMA RAILROAD RATES.

Referring to Mr. Shonts's testimony that it costs \$3.10 to handle freight across the Isthmus. This means 6 cents per ton per mile, and this fact itself is the strongest argument that can be made for providing the railroad with proper facilities and operating it in a proper manner. If this is done there is no reason why the rate can not be reduced to an average flat rate of \$2 per ton without loss of revenue.

USE OF RAILROAD TO DIVERT COMMERCE TO PANAMA ROUTE.

It is generally admitted that during the first years of canal operation the revenue will not be sufficient to pay the operating expenses and the interest on the cost of construction, even on a 2 per cent basis. For a few years this country will be expected to carry a losing investment with the hope of large gains later on. The increase will of course be gradual, year by year, as commerce is induced to use the Panama route.

The full development of the Panama Railroad will assist in causing the more rapid approach of the time when the revenues derived from the traffic through the canal will carry the investment. Consequently, if proper facilities are provided and a low flat rate established, an increase in commerce will begin at once. Even if the facilities provided at this rate make a small loss from year to year in the operation of the railroad, if it advanced to the extent of a single year the time when the canal will pay the interest on the cost of construction and its maintenance and operating expenses, the great gain will more than make up for any slight loss of revenue in the railroad in the meantime.

CANAL DUES.

[Prepared by E. L. Corthell, C. E.]

Assuming the ordinary steamship and the ordinary rules for ascertaining net register, and considering the relations between net register tonnage and "dead weight" tonnage, one being on a basis of 100 cubic feet per ton and the other on 67 cubic feet per ton (this being the average space occupied by a ton of freight), we would have for, say, a 5,000 net register ton freight steamer the following tonnages, weights, etc. It must be borne in mind that there are several kinds of tons and tonnages:

1. "Gross register tonnage," which is all the inclosed space of the vessel, and each 100 cubic feet of this gross space is a ton.

2. "Net register tonnage," which is the cargo and passenger carrying capacity of the vessel, each ton being 100 cubic feet.

3. "Dead weight tonnage," which is the whole net register space divided by 67 cubic feet for each ton, this being considered the average space occupied by average ton of freight.

4. "The charter ton," or freight ton, being 40 cubic feet.

5. "The displacement ton" equals 2,240 pounds; in metric system the weight of 1 cubic meter of distilled water equals 2,204 pounds. This is the only weight ton.

We have then for the relations and figures of the 5,000 net register ton vessel the following:

Calling load displacement	Unity.
Gross register tonnage.....per cent..	57
Net register tonnage.....do..	38
Weight of hull and motive power.....do..	44
Weight of cargo.....do..	56
Therefore—	
When the net register tonnage.....tons..	5,000
Gross register tonnage equals.....do..	7,400
Load displacement.....pounds..	13,000-2,240
Weight of hull and motive power.....do..	5,700-2,240
Weight of cargo.....do..	7,300-2,240

Assuming the rate of \$2 per net register ton for transit dues, the cargo carried will pay only \$1.36 per ton of 2,240 pounds.

SUEZ CANAL.

[Prepared by E. L. Corthell, C. E.]

Gross tonnage passing through the Suez Canal last year was 18,000,000 tons, and the net Danube measurement was 13,000,000 tons at 7½ francs per ton, or about \$1.50.

The capitalization of the Suez Canal, including betterments, is now about \$125,000,000, and it is understood that the canal now pays for itself every four years on the present basis of earnings.

Table of comparative distances in statute miles.

	Total distance.	Excess over Tehuantepec route.
	<i>Miles.</i>	<i>Miles.</i>
From New York to Hongkong:		
Via Cape Horn.....	20,379	8,777
Cape of Good Hope.....	16,945	5,243
Suez Canal.....	13,596	1,994
Panama Railroad.....	12,953	1,351
Isthmus of Tehuantepec.....	11,602	.....
New York to Yokohama:		
Cape Horn.....	19,802	9,796
Cape of Good Hope.....	18,085	8,079
Suez Canal.....	15,527	5,521
Panama Railroad.....	11,256	1,250
Isthmus of Tehuantepec.....	10,006	.....
New York to Auckland, New Zealand:		
Suez Canal.....	16,871	7,447
Cape of Good Hope.....	16,719	7,295
Cape Horn.....	13,890	4,466
Panama Railroad.....	10,305	881
Isthmus of Tehuantepec.....	9,424	.....
New York to Melbourne:		
Cape Horn.....	15,215	4,150
Suez Canal.....	15,171	4,106
Cape of Good Hope.....	15,019	3,954
Panama Railroad.....	11,826	761
Isthmus of Tehuantepec.....	11,065	.....
New York to Honolulu:		
Cape Horn.....	15,826	9,163
Panama Railroad.....	7,939	1,276
Isthmus of Tehuantepec.....	6,663	.....
New York to San Francisco:		
Cape Horn.....	15,687	10,797
Panama Railroad.....	6,063	1,173
Isthmus of Tehuantepec.....	4,890	.....
Liverpool to Hongkong:		
Cape Horn.....	20,606	5,353
Panama Railroad.....	16,471	1,213
Cape of Good Hope.....	15,722	469
Isthmus of Tehuantepec.....	15,253	.....
Liverpool to Yokohama:		
Cape Horn.....	19,400	5,945
Cape of Good Hope.....	17,653	4,198
Panama Railroad.....	14,540	1,085
Isthmus of Tehuantepec.....	13,455	.....
Liverpool to Auckland, New Zealand:		
Cape of Good Hope.....	16,221	3,412
Suez Canal.....	14,645	1,836
Cape Horn.....	13,897	1,088
Panama Railroad.....	13,312	503
Isthmus of Tehuantepec.....	12,809	.....
Liverpool to San Francisco:		
Cape Horn.....	16,562	8,250
Panama Railroad.....	8,885	609
Isthmus of Tehuantepec.....	8,276	.....
New Orleans to Hongkong:		
Cape Horn.....	20,804	10,531
Cape of Good Hope.....	17,485	7,212
Suez Canal.....	15,108	4,835
Panama Railroad.....	12,308	2,035
Isthmus of Tehuantepec.....	10,273	.....
New Orleans to Yokohama:		
Cape Horn.....	20,227	11,590
Cape of Good Hope.....	18,625	9,983
Suez Canal.....	17,089	8,402
Panama Railroad.....	10,611	1,974
Isthmus of Tehuantepec.....	8,637	.....

Table of comparative distances in statute miles—Continued.

	Total distance.	Excess over Tehuantepec route.
New Orleans to Auckland, New Zealand:	<i>Miles.</i>	<i>Miles.</i>
Suez Canal.....	18,381	10,286
Cape of Good Hope.....	17,259	9,164
Cape Horn.....	14,314	6,219
Panama Railroad.....	9,669	1,564
Isthmus of Tehuantepec.....	8,096	
New Orleans to Melbourne:		
Suez Canal.....	16,643	6,947
Cape Horn.....	15,640	5,904
Cape of Good Hope.....	16,560	5,824
Panama Railroad.....	11,181	1,445
Isthmus of Tehuantepec.....	9,736	
New Orleans to Honolulu:		
Cape Horn.....	16,251	10,917
Panama Railroad.....	7,294	1,960
Isthmus of Tehuantepec.....	5,394	
New Orleans to San Francisco:		
Cape Horn.....	16,112	12,551
Panama Railroad.....	8,418	1,657
Isthmus of Tehuantepec.....	8,561	

In considering the saving in the value of distances by either the Panama Railroad or the Tehuantepec route it is reasonable to take 250 miles a day as the average rate of speed of a cargo steamer and the average rate of ocean freight as approximately a dollar a ton in weight for each 1,000 miles.

STATEMENT OF COL. OSWALD H. ERNST,

U. S. ARMY,

**BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.**

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ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Monday, March 26, 1906.

The committee met at 2 o'clock p. m. (only an executive session having been held on Wednesday last).

Present: Senators Millard (chairman), Kittredge, Dryden, Knox, Ankeny, Morgan, and Taliaferro.

STATEMENT OF COL. OSWALD H. ERNST, U. S. ARMY.

The CHAIRMAN. General Ernst, will you be kind enough to give the stenographer your name and rank?

Colonel ERNST. O. H. Ernst; colonel, Engineer Corps, U. S. Army.

The CHAIRMAN. And your present position?

Colonel ERNST. I am now a member of the Isthmian Canal Commission.

The CHAIRMAN. When were you appointed a member of the Commission?

Colonel ERNST. I was appointed a member of this Commission on the 1st of April last.

The CHAIRMAN. You have been an engineer in the Army for a good while?

Colonel ERNST. Yes, sir; I graduated at West Point in 1864, and have served in the Corps of Engineers ever since—forty-two years.

The CHAIRMAN. Now, Colonel, we would like to have you, as a member of the Commission and an army engineer, give us your experiences upon the Isthmus and your judgment in regard to the work which is going on there at the present time. You have been on the Isthmus, as I understand it, a good many times?

Colonel ERNST. Yes, sir. The last time I was there was in October, and I found things in a very favorable situation. The temper was excellent; the tone of the force employed there was first-rate. The men in charge seemed to me to be earnest and capable. They were getting supplies with reasonable promptness, and I felt very much encouraged.

The CHAIRMAN. When were you there previous to that time, and how long were you there?

Colonel ERNST. I was there in July, also, of this last year.

The CHAIRMAN. Were you ever there prior to July?

Colonel ERNST. I was there in 1899—the spring of 1899 and 1900.

The CHAIRMAN. When the French company was in charge of the work?

Colonel ERNST. Yes, sir.

The CHAIRMAN. Now, Colonel, we want your best information in regard to matters as they exist there, and particularly in regard to the two plans of canal that have been submitted.

Colonel ERNST. I have made a very careful review of all the arguments presented on both sides as exhibited in these two reports which you have before you—the majority and the minority reports—and I am satisfied that the United States will get a perfectly satisfactory canal in very much less time and for very much less money under the plan proposed by the minority. I believe that the canal under that plan will cost little more than half what the canal of the majority will cost, and the time will be a little more than half, and when done it will be a better canal, because it will be three times as big a canal. The volume of water in the sea-level canal is only one-third what the volume of water is in this lock canal. Leave out everything in those lakes beyond the width of 1,000 feet and everything beyond a depth of 45 feet and you have three times the number of cubic yards of water in the lock canal that you have in the sea-level canal.

If we could eliminate the locks it would be a fair statement to say that the lock canal offers three times the facilities for navigation that the sea-level canal does.

Senator KITTREDGE. Just a minute, Colonel. What about the canal going through the Culebra cut? Do you say that the canal going through that cut offers three times the facilities for navigation?

Senator KNOX. He is speaking of it as an entirety.

Colonel ERNST. I am speaking of it as an entirety—as a waterway.

Senator KITTREDGE. Right there, is not the capacity of your canal limited by the maximum capacity in any particular part?

Colonel ERNST. No, sir.

Senator KITTREDGE. By the maximum capacity in the Culebra cut, for instance?

Colonel ERNST. No, sir. The size of vessels is limited, but not the capacity of the canal. The capacity of the canal varies with the facilities.

Senator KITTREDGE. Is not the capacity of your canal limited by the capacity of your locks?

Colonel ERNST. Oh, yes; not the capacity of the canal, necessarily, but the size of the ships.

Senator KITTREDGE. Is not the capacity of your canal for usable purposes limited by the capacity of your locks?

Colonel ERNST. It depends a good deal, Senator, on what we mean by "capacity."

Senator KITTREDGE. I mean the number of ships that can pass through.

Colonel ERNST. Yes. Now, what I say is that the capacity of a waterway which is 1,000 feet wide for a large part of its distance and 45 feet deep or more is greater than the capacity of a canal which is only 200 feet wide or 150 feet wide and 40 feet deep, notwithstanding that one can not take any bigger vessels than the other. I mean the facilities, the ease with which they can get through and pass each other.

Senator KITTREDGE. You mean, then, to make that statement upon the basis of eliminating the locks and eliminating the narrow passage through the Culebra Cut?

Colonel ERNST. I was going on to say that these are to counterbalance each other. One canal is three times as big as the other; but the one has these locks, which are an objection on the other side.

Senator KNOX. You mean that the area of the waterway in the lock canal is three times as great as the area of the waterway in the sea-level canal in its entirety? Is not that what you mean?

Colonel ERNST. Yes; only not area, but volume—cubic volume.

Senator KNOX. Volume?

Colonel ERNST. Yes; that is what I say. That is one of my reasons for thinking that it is a safer waterway.

Senator TALIAFERRO. But in connection with the inquiry of Senator Kittredge, you can not get any more vessels through that larger waterway than you can get through your narrow locks or your narrow cut through Culebra?

Colonel ERNST. They all have to go through the locks, of course; but what I mean to say is that you get greater speed.

Senator TALIAFERRO. After they get through?

Colonel ERNST. Yes; except they are detained at these isolated points. When they are elsewhere, for the rest of the 47 miles, they have a free, open waterway where they can go at much greater speed and with much less risk of collisions or groundings, or anything of that kind.

The CHAIRMAN. Now, Colonel, if you are ready, be kind enough to proceed.

Colonel ERNST. The plan as it was laid out by the minority has straight courses. You can guide a vessel through submerged banks very much better in a canal with straight courses than you can where they are all curved. They make their changes all at one place; they run along a straight course and then make a change and then run along another straight course. That has been found a very great advantage in the channels between the Great Lakes.

Senator MORGAN. When making the changes that you speak of, Colonel, do they have to stop the ship?

Colonel ERNST. No, sir; they just slow up at the curves. Instead of keeping on a turn all the time, they run straight up to the angle, and there the channel is widened out.

Senator MORGAN. It is practically a stopping of the ship, is it not? It is a slowing up?

Colonel ERNST. It is a slowing up.

Senator MORGAN. You slow up when you reach certain points, and then you take a new course?

Colonel ERNST. Yes.

Senator MORGAN. And steer for that?

Colonel ERNST. Yes.

Senator DRYDEN. Do you remember how many of those angles there are in the lock canal?

Colonel ERNST. I do not remember, but we can easily count them. They are all exhibited here. Shall I count them?

Senator DRYDEN. If you please, yes; and in counting them kindly point them out on the map.

(Colonel Ernst thereupon pointed out on the map the locations of the angles referred to and stated that there were nineteen of them.)

Senator DRYDEN. That is about one to every 2 miles?

Colonel ERNST. Yes, sir.

Senator DRYDEN. Just a little less than one every 2 miles on an average. The point you make upon that is that these are well-defined angles, and that the ship can make greater progress by turning the angles, even if at slow speed, and then having a straightaway course, say, for 2 miles, than it could by going around the curves that exist in the sea-level scheme. Is that it, Colonel?

Colonel ERNST. Yes, sir; that is it. They are much more easily marked.

Senator DRYDEN. Do you know how many of those curves there are in the sea-level scheme?

Colonel ERNST. It is stated in the report. I can find that for you. I do not recall.

Senator DRYDEN. You need not look it up.

Colonel ERNST. It is an almost continuous curvature.

The CHAIRMAN. Colonel, the dark covered book there has both reports in it, and everything connected with the reports of the Board.

Senator MORGAN. Giving the same depth and prism to the canal, there is no more difficulty in steering through a sea-level canal than through a lock canal, is there?

Colonel ERNST. Only for the reason that in one you have straight courses and in the other you have continuous curvature or almost continuous curvature.

Senator MORGAN. How do you get a straight course in the lock canal through the Culebra cut? The curves are just the same, are they not, in the lock canal and in the sea-level canal through the Culebra Heights?

Colonel ERNST. Not quite the same. In the lock-canal plan they have paid great attention to that feature, and in the other they have not. That is the difference. There is some slight difference in the Culebra cut. There need not be, however. It is not necessary that there should be, but as a matter of fact they paid no particular attention to that feature of having straight courses. They thought that if the curvature was gentle that was all that was necessary; but I regard having the courses absolutely straight as an advantage.

Senator MORGAN. It is practicable to make a straighter line with the lock canal through the Culebra Heights than it is with sea-level canal?

Colonel ERNST. No, sir; it is not.

Senator MORGAN. The line would have to be practically the same?

Colonel ERNST. Pretty nearly the same thing; and if you keep that in view, it is just as easy to make one as the other.

Senator KITTREDGE. You say "pretty nearly the same." In what respect, and where, are they at all different?

Colonel ERNST. Simply in laying down the lines on the map by the engineer; if he takes particular pains to get his lines straight, he will cut off a little more, perhaps, than he would otherwise.

I believe those cover the reasons why I prefer the minority plan. There have been one or two points raised in the evidence which has been before you, Mr. Chairman, which I would like to refer to, unless some one has other questions to ask.

The CHAIRMAN. You may proceed.

Colonel ERNST. On page 1760 of the evidence I read this—Mr. Parsons was on the stand. [Reading:]

"Senator KITTREDGE. Then, as I understand you, notwithstanding the statement in the minority report of the usable dimensions of this

lock as 900 feet by 95 feet, in the plan presented to us the usable dimensions are in fact 790 feet as to length?

"Mr. PARSONS. That is a fact.

"Senator KITTREDGE. By what width?

"Mr. PARSONS. Ninety-five feet.

"Senator KITTREDGE. Is it not possible to lengthen the entire lock structure so as to have a usable length of 900 feet?

"Mr. PARSONS. It is not possible to do that and still keep the three locks in flight.

"Senator KITTREDGE. Why is that?

"Mr. PARSONS. The topography of the ground (is such), falling off at both ends, that you could not get a longer structure in there."

Then, farther on down:

"There is a divide there, a ridge, with suitable material for foundations, rock or a very hard clay amounting almost to a rock, and at such reasonable depth as to be reached by the locks. But when you come to make the locks of a thousand feet each, with the space between the locks for the gates and the clearances between the locks, the ends of that structure would overhang the sides of this ridge so that the ends would not have a proper foundation. The ends would include, of course, the end gates at both ends, where it is most important that there should be a satisfactory foundation.

"The minority, therefore, decided not to use 1,000-foot locks. In other words, three members of the minority reversed themselves in their original decision of a thousand feet and dropped back to a 900-foot lock, so as to get in three locks of 900 feet each in this situation.

"Then, when an objection was made to the danger of locks in flight, they still further reduced it, as Mr. Bates has pointed out, by introducing the safety gates, the second set of gates, and by putting them inside of the 900-foot length.

"Senator KITTREDGE. And thereby reducing the usable length dimension to less than 800 feet?

"Mr. PARSONS. To something less than 800 feet."

The CHAIRMAN. That refers to the locks at Gatun, I presume?

Colonel ERNST. Yes, sir.

Now, as for the site, we have a cablegram from Mr. Stevens, which I believe is on file——

The CHAIRMAN. By the way, Colonel, right here I will hand you these cablegrams, and will ask you to look them over and comment on them, and then allow them to go into the record. This one appears to have been sent by Mr. Stevens to Mr. Shonts and the other is to the Secretary of War. If you will have the kindness to look those over and read them to the committee and then comment on them, I would like to have them in the record after you are through with them.

Colonel ERNST. Here is a telegram dated March 17 from the chief engineer on the Isthmus, Mr. Stevens.

The CHAIRMAN. I think you should read the other one first—the one to Mr. Stevens.

Colonel ERNST. The one from Mr. Shonts?

The CHAIRMAN. Yes. It seems to have been from Mr. Shonts to Mr. Stevens.

Colonel ERNST. Mr. Shonts, after this evidence was given, telegraphed this to Mr. Stevens:

Confidential.]

MARCH 16, 1906.

STEVENS, *Panama*:

Burr and Parsons testified in favor sea level and strongly against lock, asserting Gatun Hill not large enough to permit construction three locks in series with usable length exceeding 790 feet each, and proper foundation dam not attainable. Noble testified in favor of lock canal, but had no figures to refute statements about length Gatun Hill.

SHONTS.

MARCH 17, 1906.

SHONTS, *Washington*:

Cablegram of 16th received. I have just made careful personal examination exact site Gatun dam. There is ample length with perfect foundations for longer locks than reported by minority of board. Contradict Burr and Parsons on my authority, and say that if nature had intended triple locks there she could not have arranged matters better.

STEVENS.

The Secretary of War also telegraphed to Mr. Stevens, on the 18th of March, as follows:

MARCH 18, 1906.

STEVENS, *Panama*:

Would it not be wise for you to examine and measure Gatun Hill with reference to the question raised by Burr and Parsons? It ought to be done, if done at all, at once.

TAFT.

Reply, dated March 20, 1906:

ISTHMIAN, *Washington*:

Replying to Secretary Taft cable, 18th, I say limits in length required for twin triple locks, Gatun, 3,100 feet; in width 300 feet. Have fully developed by one hundred borings, 3,800 feet in length and 300 width, on exact site, perfect foundations, and can build two sets of three locks, each 1,150 feet long if necessary, and perhaps much longer. Conditions ideal for construction and permanency.

STEVENS.

Senator MORGAN. Is that two sets in flight, or three, that you mention?

Colonel ERNST. Three.

Senator MORGAN. Three in flight?

Colonel ERNST. Yes, sir; they are double, but there is a flight of three.

Senator KITTREDGE. What was the total length that he found there?

Colonel ERNST. He says enough to make—

Senator KITTREDGE. I mean the total length.

Colonel ERNST. He says enough to make three locks 1,150 feet long each.

Senator KITTREDGE. Does that mean that the aggregate length suitable for the lock structure is three times 1,150 feet?

Colonel ERNST. Yes, sir; that is what that means.

Senator MORGAN. Three times 1,150 feet?

Senator KITTREDGE. That means there is 3,450 feet there?

Colonel ERNST. Yes, sir; it means more than that. It means that there is that plus the space required for the structure outside of the locks themselves.

Senator KITTREDGE. That is what I was getting at.

Colonel ERNST. That is the way he describes it—that it is abundant to build locks 1,150 feet long or more, but of course you can not build a lock without giving the proper supports outside of the locks themselves.

It is stated here in the first place that they cut down their length from 1,000 to 900 feet because they did not have room. That shows that that was not the reason.

It is stated also that the 900 feet is short. Now, here is the original drawing filed with the Commission, which I brought up here so that you could see for yourselves. It covers four different studies. The only one which we are concerned with now is this one [indicating], which is the Gatun locks in flight of three. I have had a tracing taken of that part, but I thought I would bring the whole thing here so that you can see that this is the original drawing filed by that Consulting Board.

In describing a lock engineers have to use two lengths, one being the total length of the chamber, which they use in computing the volume of water that is required to fill it, but in that must be included room enough for the gates to swing. You can not put in a ship the total length of the chamber. So they have another length that they call the usable length, which is less.

Senator KITTREDGE. What is the difference between the two?

Colonel ERNST. What is the difference?

Senator KITTREDGE. Yes.

Colonel ERNST. In this case it is 55 feet.

Senator KITTREDGE. At each end?

Colonel ERNST. No, sir; the total length. The length here, between point posts, from quoin to quoin—perhaps the better expression would be “gateposts.”

Senator KITTREDGE. I understand what they are.

Colonel ERNST. The distance between the gateposts in this case is 955 feet. That is adjusted so as to give 900 feet clear, allowing for these gates to swing.

Senator KITTREDGE. Do you not have gates swinging at each end of your lock structure?

Colonel ERNST. Not swinging in the chamber; they are outside. They do not swing both ways, you know. Here is the chamber. The gates have to swing around into these recesses at that end [indicating]. They do the same thing at this end [indicating], but of course they do not interfere with the length of the lock chamber.

The distance from quoin to quoin—that is, between the gate posts—in this case is 955 feet in order to give 900 feet of usable length. It

is said that in that upper lock they have put this guard gate into that chamber and have encroached on it in that way. They have put it into the chamber, but they have not encroached on it.

Senator KITTREDGE. I wish you would tell us just why they have not made that encroachment.

Colonel ERNST. That is what I had this diagram made for. This [referring to diagram] is upstream. You see, the gates all point that way. This is upstream. In the case of a boat entering the lock upstream both these gates stand open. The boat comes down here to this gate and stops. This upper gate is then closed. Now you have got three gates closed. Then this gate is opened; the boat is pushed forward 80 feet—

Senator KITTREDGE. How pushed forward?

Colonel ERNST. By capstans, or whatever power is used for moving the boat. She is moved forward by her own power, or by some other power; probably by capstans.

Senator KITTREDGE. What distance?

Colonel ERNST. Eighty feet. This does encroach if you want to close all the gates at the same time; it does encroach 80 feet in that event. The distance here, between these two quoin posts, is 80 feet, but it does not prevent your putting through there a 900-foot boat and still having your summit level protected at all times by two or three gates; never less than two gates. The ship comes in here, and this gate is closed behind her. This one is open. She goes forward 80 feet and stops there.

Senator KITTREDGE. And stops, you say?

Colonel ERNST. And stops; yes. The difference is that it takes from seven to eight minutes longer for the ship to get through. That is the difference.

Senator KITTREDGE. After she stops, what happens?

Colonel ERNST. Then this other gate is closed.

Senator KITTREDGE. Which other gate?

Colonel ERNST. This second gate. Here are two gates.

Senator KITTREDGE. You mean by "the second gate," the safety gate?

Colonel ERNST. Well, we usually call the upper one the guard gate; but the second gate is closed, that gate [indicating] is closed, and there is the position [indicating]; and there are still two gates always protecting the upper level.

Senator KITTREDGE. If it does not interrupt you, I would like to know a little more about that situation. Your safety gates are in your upper lock; is that right?

Colonel ERNST. One is inside and one is outside.

Senator KITTREDGE. But they are connected with your upper-lock structure?

Colonel ERNST. Yes, sir; yes, sir.

Senator KITTREDGE. Now, where with reference to the structure are the safety gates? Describe it so that it will appear in the record.

Colonel ERNST. I do not think I understand that.

Senator KITTREDGE. Do you have safety gates at each end?

Colonel ERNST. Yes.

Senator KITTREDGE. Now, how far—

Colonel ERNST. Oh, I think I do understand you now. Ordinarily there would be simply one gate at each end. For the purposes of safety

an additional gate is put up, which we call guard gates or safety gates. One of those is put outside of this space which has been devoted, we will say, to a lock without safety gates. The other one is put inside. The distance which this is above that one is 80 feet.

Senator KITTREDGE. Do not say "this one above that one;" describe it so that we can put it into the record.

Colonel ERNST. The distance of the quoin post of the guard gate from the other gate is 80 feet; and it would encroach that much on the usable length of the lock if you had to keep all your gates closed at the same time.

Senator KITTREDGE. In other words, it would reduce the usable length to 820 feet? Is that it?

Colonel ERNST. That is it. Yes; exactly—if you had to close all your gates at the same time; but you do not have to do that.

Senator KITTREDGE. Suppose you put a ship 900 feet in length into that lock; describe exactly what would happen in putting that size of ship through that lock?

Colonel ERNST. Yes, sir; that is what I was trying to do. She comes in here, we will suppose; both the upstream gates are open; she enters the lock—

Senator KITTREDGE. From the upstream end?

Colonel ERNST. From the upstream end. She enters the lock until she reaches this gate [indicating].

Senator KITTREDGE. And at what distance is the gate you now point to from the upper end of the lock?

Colonel ERNST. From this point to this point [indicating] is 955 feet.

Senator KITTREDGE. At what distance from the gate?

Colonel ERNST. From that gate, the second gate, 820 feet; but those gates are open.

Senator KITTREDGE. I understand.

Colonel ERNST. The ship is sticking out through those gates, and after she has gotten here and come to a stop these gates are closed.

Senator TALIAFERRO. The outer gates are closed?

Colonel ERNST. The outer gates are closed. That leaves those gates and these gates [indicating] still to protect the summit level; and you are free to open that gate [indicating], which you do. The ship is then pushed forward 80 feet, and stops again. Then this gate [indicating] is closed, and that leaves the two up there [indicating] to protect the summit level, and you are free to open that gate, which you do, and the ship goes out.

Senator TALIAFERRO. What is the usable length of the lock with all the gates closed?

Colonel ERNST. Eight hundred and twenty feet.

Senator KNOX. What is the usable length with the gates open, which you say may be safely opened after the vessel goes in?

Colonel ERNST. Nine hundred feet.

Senator KNOX. So that is the maximum usable length?

Colonel ERNST. Yes, sir.

Senator KITTREDGE. What do you put those safety gates in there for?

Colonel ERNST. So that there would always be two gates to protect the summit level.

Senator TALIAFERRO. Under this arrangement there is only one when you close both gates in the rear, or at the entrance of the lock? When

you close both gates you have only one gate to protect that at the other end?

Colonel ERNST. Yes; but down here (the ship is supposed to come down, now, to this level) you have these two gates; you always have two.

Senator KITTREDGE. At which end?

Colonel ERNST. In this case, now, they are up there; when the ship is moved forward to this place, both are at that end [indicating]. First they are both at this end [indicating]; then one is at this end and one at this end, and then they are both at that end [indicating].

Senator TALIAFERRO. Which is the summit level end of the lock, Colonel?

Colonel ERNST. This, upstream [indicating].

Senator TALIAFERRO. You do not mean that you can put a 900-foot ship through that lock and have at all times those two upstream gates closed, do you?

Colonel ERNST. Not those two gates, no; we can have one of them closed—one there and one there [indicating].

Senator TALIAFERRO. Then it is a fact that you have not at all times your summit end of the lock protected by two gates when you are putting through a ship 900 feet long?

Colonel ERNST. Oh, yes; this gate is precisely on the same footing with that gate. They are all holding the same level of water. There is no difference in the level. We will suppose this lock to have been filled up to the level. There is not the slightest trouble about that; there are always at least two gates to protect the summit level.

Senator KNOX. But not always at the same end of the lock?

Colonel ERNST. But not always at the same end of the lock; that is it exactly.

Senator DRYDEN. You are speaking now, Colonel, of the locks as designed and recommended by the minority of the engineers. In that connection, how do you interpret these communications from Engineer Stevens as to the possibility of making longer locks there if it is deemed necessary and advisable?

Colonel ERNST. Well, there is a difference of opinion here, you know, about how long those locks ought to be.

Senator DRYDEN. Yes, but suppose it should be finally determined that locks longer than originally suggested should be made; that locks of 1,000 feet usable length should be put there. Do you understand Mr. Stevens to say that the formation of the mountain and the land is such that these locks can be made of such a length?

Colonel ERNST. I do; yes.

Senator DRYDEN. That is the point I wanted to get at.

Colonel ERNST. That is as I understand it.

Senator DRYDEN. And Mr. Stevens, you understand, states that from an actual examination of the land, the conditions there since these doubts were thrown upon the possibility of making locks of that length?

Colonel ERNST. Yes, sir.

Senator DRYDEN. With a view of ascertaining whether or not they should be made longer?

Colonel ERNST. Yes, sir; that is what I understand.

Of course this involves losing eight or ten minutes in going through, although it is a perfectly safe thing to do. You still have the usable length of 900 feet, with the two gates always protecting the summit

level. It would be possible to make this lock long enough to shut all the gates and still have 900 feet between them. There are some objections to that, but that is a possibility. The objections are that you want about the same cubic volume of water in one lock as in the other; and if you increase the length of this lock above that of the others, you ought to decrease the lift. That can be done and make the volume the same, with a greater length and less lift; but that has the objection that your gates are different. It is an advantage to have the gates all duplicates of each other. They sometimes get out of order, and it is a desirable thing to have them all duplicates; and it strikes me that this is the best arrangement they could make. But it is not so that they can not put a 900-foot boat through there with perfect safety—I mean, having two gates always to protect the summit level.

Senator DRYDEN. Do you know of any reason why, if it is thought necessary to make these locks longer, there should be any mechanical or structural difficulty about doing it?

Colonel ERNST. None in the world; none in the world. It is the easiest way to enlarge a lock that there is, to increase the length of the wall.

Senator DRYDEN. Could they be made longer with just as much safety as the length originally suggested?

Colonel ERNST. Absolutely; certainly.

Senator DRYDEN. And in facility of operation they could be operated as easily, could they?

Colonel ERNST. Yes, sir; just as easily.

Does any gentleman want any further explanation on that point?

The CHAIRMAN. Have you a statement there that you wish to read to the committee?

Colonel ERNST. No; I have no written statement, but there is another point in the evidence that I would like to allude to.

Senator DRYDEN. Before you pass to that, Colonel, it has been stated here that there is danger of these locks being smashed down and destroyed by the weight and operation of the vessels passing through. I would like to have your opinion upon that matter.

Colonel ERNST. I do not think there is any more danger of that, Senator, than there is in coming up in this elevator that we come up in every day to this committee room. There are people in the world, plenty of them, who would be afraid to come up on that elevator, and the engineers who have had the greatest familiarity with locks are those who are the most perfectly satisfied of the perfect safety of making these new locks, these large locks.

I have watched the Soo Canal for a good many years. I had general supervision of that district of country before coming here, and I am just as satisfied that those locks can be built as I am of anything else in the world. I have no doubt about it at all.

Senator KITTREDGE. What is the maximum lift at the Soo?

Colonel ERNST. The lift is about 20 feet.

Senator KITTREDGE. One lock?

Colonel ERNST. One lock, 20 feet lift; yes.

Senator KITTREDGE. Do you think that condition at the Soo is to be compared with the condition at these Gatun locks?

Colonel ERNST. Oh, yes. It is on a smaller scale. Oh, I think we should take our lessons from the Soo. I rely very greatly on the experience at the Soo. It is the best experience there is.

The navigation interests of the Great Lakes are enormous, the commerce is growing with marvelous rapidity. It is not afraid of those locks. They are clamoring now for deeper channels between the lakes. They want more than 21 feet, and when they get them they will want bigger locks; and they know that perfectly well. They are not afraid of them. The trade is growing enormously. Last year it beat all records.

Senator KITTREDGE. What was the tonnage capacity?

Colonel ERNST. About 45,000,000 tons went through the Soo canals, those three canals, of which this Poe lock takes much the greater part.

Senator KNOX. How does that compare with the Suez Canal?

Colonel ERNST. It is more than three times as much.

Senator KITTREDGE. In speaking about the tonnage passing through there, you mean through the British canal as well as ours?

Colonel ERNST. Yes. The British canal takes about 10 per cent.

Senator KITTREDGE. How much went through ours?

Colonel ERNST. Ours takes 90 per cent of it.

Senator KITTREDGE. Figured in tons, how much was it?

Colonel ERNST. A little over 40,000,000 tons. Ten per cent of 45,000,000 would be four and a half. About 40,000,000 tons went through our locks.

I do not know but that it is proper to call attention to the continuation of Mr. Parsons's testimony the next day, having referred to his evidence, to which I have just replied. After that evidence that I have quoted before, this is what he says the next day:

"I am not attacking the ability to construct those locks at all. I want to have that distinctly understood. But, at the same time, if the locks are built, when they are built they will be unsafe for operation, in my opinion, as I explained yesterday. In other words—I lay stress not upon the inability to construct the locks or the inability to make those locks 1,000 feet long, if necessary—I believe that the ground is probably there to build the locks on and that the locks can be built a thousand feet long, if it is necessary, but that if that is done you will still have locks that are unsafe to operate, on account of the locks being in series of three."

So that he toned down a little the evidence he gave; but I thought it was desirable to explain to the committee that that minority report said exactly what they intended to say, and they furnished plans for locks that could pass a boat 900 feet in length.

✓ Senator KITTREDGE. If it is a convenient time I would like to have your views upon the lock structure from a military standpoint.

Colonel ERNST. Senator, I do not believe in making that canal a subject of the operations of war at all. I agree entirely that it is easier to destroy a lock with a stick of dynamite than it is anything else upon the canal. But I believe that both canals are utterly vulnerable, and that the best defense we have is to make them neutral and to put our citizens in charge of them.

Senator KITTREDGE. Suppose the canal had been in operation in 1898, and we had wanted to put the Oregon through—would you have prevented that ship from passing through?

✓ Colonel ERNST. Oh, no; my idea of neutrality is that all vessels, men-of-war and commercial vessels, will go through just the same as if there was not any war. I believe that is correct.

Senator KITTREDGE. Would you have been in favor of permitting the ships of Spain to pass through there?

Colonel ERNST. If she would take the risk; but I know very well she would not. I know very well that no commander of a vessel would put his ship in that canal if the lock keepers, and the pilots, and everybody in charge of it were Americans, if his nation was at war with America.

Senator KITTREDGE. What do you mean by putting the canal upon a neutrality, then?

Colonel ERNST. I mean to give everybody the free use of it if they are not afraid to use it; but what I think is this: That a foreign commander would be simply afraid to use it, no matter what our Government might promise. We have men down there of all kinds, and somebody would be bound to sink his vessel for him.

Senator KITTREDGE. Do you consider this canal, when constructed, useless from the military standpoint.

Colonel ERNST. Oh, no; not at all. I think our people would use it. We would have our citizens there; that is the difference. If it were a neutral canal, with French citizens or Spanish citizens in charge of it, then it would not be of any use to us; but having our citizens in charge of it I think we could use it with safety.

Senator TALIAFERRO. You mean you would advertise neutrality, but operate the canal in such a way that people that were at war with this country would not go into it? [Laughter.]

Colonel ERNST. Well, I simply take human nature as I find it. That is what I believe would be the result. I would advertise neutrality, and keep it, too, as far as I was able to do it; but I know very well I could not do it. I know that even if we thought we could do it the foreigners would be suspicious of it and be afraid to use it. That is what I believe in the matter.

Senator MORGAN. Colonel, in this neutrality matter, if you were in command of a fleet or an army at Panama and the United States Government was at war with Great Britain or Germany, would you consider that under the laws of neutrality you were obliged to allow ships of war of Germany or of Great Britain to pass through that canal, knowing that they were going up to attack San Francisco, or the border up there?

Colonel ERNST. I suppose that is what neutrality would mean, would it not, Senator? You know much more about it than I do.

Senator MORGAN. I have not that view of it. I have always supposed that the nation that controls the channel, it not being a public, international channel, has the right to say, among nations that are belligerent with each other, but not belligerent with the United States, "You shall pass through here on equal terms; but when you open belligerency with the United States we will take our ground to fight you at the mouth of the canal, if it is necessary to do it."

Colonel ERNST. Yes—well, of course, I do not know how far the term "neutrality" would extend; but I think that no British commander would put his ship through there if our people had charge of the locks, if we were at war with Great Britain, no matter what we promised.

Senator MORGAN. And we would not put our ships there if we were at war with Panama, either; would we?

Colonel ERNST. No; I would not put my ship there, except in case of urgent necessity, if we were at war with anybody, no matter who it might be. I do not think that any captain would have his ship in there any longer than was absolutely necessary.

Shall I pass to the other point?

The CHAIRMAN. Yes, sir.

Colonel ERNST. On page 1496 Mr. Burr was testifying, and he makes this statement:

"In the work of the first Isthmian Canal Commission, where it was the duty of that Commission to determine the most practicable and feasible route for a ship canal, it was the unanimous opinion of that Commission that for its purposes a lock canal should be recommended, as it was recommended. That recommendation was largely for the tentative purpose of making a comparison between the Nicaragua and the Panama routes. In order to make a proper comparison, a comparison which might be considered fair and reasonable, it was necessary to make it upon the basis of a lock plan for each, because it would not be practicable or feasible in any sense of the word to construct a sea-level canal on the Nicaragua route."

On page 1498 I find the following:

"Senator MORGAN. In other words, you did not consider yourself committed by signing that report—joining in it—to the proposition that a sea-level canal at Panama was impracticable?"

"Mr. BURR. Not necessarily. I felt—and I am sure at least one other member of the Commission also felt—that our investigations were not sufficiently extended. It was not possible at that time to extend them sufficiently to settle that question finally."

"Senator KITTREDGE. Who was the other member of the Commission?"

"Mr. BURR. I refer to Mr. Morison."

Now, Mr. Chairman, that point is of importance, because it raises the question of good faith—our national good faith. That Commission did adopt a plan. It said, in as plain language as I can conceive of, that it adopted it and recommended it. There was nothing tentative about it, and it proceeded to appraise the value of the French property on that basis. The French had taken out some 77,000,000 cubic yards of material. Under that plan a large part of that material was not of any value, and we allowed them, I think, for some 39,000,000 cubic yards.

Senator KITTREDGE. Which plan do you now refer to?

Colonel ERNST. The plan that was recommended by the Commission of 1901.

Senator KITTREDGE. You mean the Commission that was appointed in 1899 and made its report in 1901?

Colonel ERNST. Yes, sir; the Commission of 1899–1901.

Senator MORGAN. The Commission of exploration under Walker.

Colonel ERNST. It was a commission appointed to report on all the routes. I was instrumental in getting up the report of that Commission, particularly the Panama chapter, and I worked in close alliance with Mr. Morison. He was with me in the work throughout. I know exactly what his views were; and here is a sentence which he wrote, ending up the paragraph discussing the sea-level plan. This is Mr. Morrison's own language:

"While such a plan would be physically practicable, and might be

adopted if no other solution were available, the difficulties of all kinds, and especially those of time and cost, would be so great that a canal with a summit level reached by locks is to be preferred."

There is nothing tentative about that.

As I say, if it was tentative, it was only fair to let the French Company know it. But we did not do that, and we allowed them for 39,000,000 cubic yards of material.

Senator KNOX. I do not just get your point as to where the good faith of the Government was involved.

Colonel ERNST. The French had expended a very large amount of money on the Isthmus, and they valued their property at a very large sum of money.

Senator MORGAN. They had spent \$260,000,000, had they not?

Colonel ERNST. Yes, sir; that was in hard cash that got into their treasury.

Senator MORGAN. And they got it almost two-fifths done?

Colonel ERNST. Well, yes, roughly; under some plans, you may say it was two-fifths done.

Senator KNOX. Just finish that answer where you were speaking about the good faith.

Colonel ERNST. They had estimated that they had removed 77,000,000 yards of material. We rejected all of that except what was useful under this plan.

Senator KNOX. Why did you reject it?

Colonel ERNST. Because it was not of any value to us. We expected to build the canal under that plan, and we thought it was fair to pay them for such of their work as would be useful under that plan.

Senator KNOX. Under what plan?

Colonel ERNST. The plan of 1901—the Commission of 1899–1901.

Senator KNOX. Being a lock scheme?

Colonel ERNST. Yes, sir.

Senator MORGAN. With a dam at Bohio; and what was the elevation?

Colonel ERNST. Eighty-five feet.

Senator MORGAN. Eighty-five feet, and a dam at Bohio?

Colonel ERNST. The same as this elevation, but with a dam at Bohio instead of Gatun. I am merely raising the point that that was not a tentative plan.

Senator KNOX. Then your point about "good faith" is that they would have been entitled to compensation for the full amount of the excavation had we contemplated building a sea-level canal which would have made that excavation useful?

Colonel ERNST. Yes; perhaps not the full amount, but a very much larger amount.

Senator KNOX. Yes.

Colonel ERNST. Instead of 39,000,000 perhaps they would have been entitled to some seventy-odd million.

Senator KNOX. Do you think that that in anyway estops us from building any sort of a canal we see fit to build?

Colonel ERNST. Oh, no; I do not think that.

Senator KNOX. Then how is our good faith involved in the matter?

Colonel ERNST. The good faith of that Commission is involved in having appraised a property at a certain value when it was worth a great deal more.

Senator KNOX. But this Government was not bound to adopt the views of that Commission; and if the French company chose to sell upon the tentative view of the Commission and accept pay for a less amount of excavation, this Government is not acting in bad faith in rejecting that Commission's view and building upon some other theory, even though it would involve the use of that excavation for which they did not receive compensation.

Colonel ERNST. I think that we, in equity, should pay them something more.

Senator KNOX. The logic of your suggestion is that if we do go on and build a sea-level canal we still should pay them some more money?

Colonel ERNST. Yes, sir.

Senator KNOX. I have no doubt they would agree to that, but I would not. (Laughter.)

Senator MORGAN. How far was that Bohio dam from the Gatun dam? How many miles.

Colonel ERNST. About 7 miles.

Senator MORGAN. At the time that you recommended the dam at Bohio at an 85-foot elevation, and made estimates of the cost of construction and the time of construction, etc., it was understood that that was recommended as a plan of construction, was it not?

Colonel ERNST. Yes, sir.

Senator MORGAN. And the only plan that they did recommend?

Colonel ERNST. Yes, sir.

Senator MORGAN. At that time was any test made or had any test been made of the site that is proposed by the minority for the dam at Gatun?

Colonel ERNST. There had been some; yes.

Senator MORGAN. Why were not those tests prosecuted at that time to ascertain whether the dam that is now proposed by the minority was feasible?

Colonel ERNST. It was believed by the majority of that Commission that the Gatun site was not available.

Senator MORGAN. You have changed your opinion since that time?

Colonel ERNST. Yes, sir.

Senator MORGAN. You believe that the Gatun site was available?

Colonel ERNST. Yes, sir.

Senator MORGAN. And you have changed that opinion?

Colonel ERNST. Yes; but not for the reason that I could not build that dam. I have changed my opinion.

Senator MORGAN. But not for that reason?

Colonel ERNST. No, sir.

Senator MORGAN. Mr. Wallace's borings carry the depth down to rock below sea level, 40 feet farther down than you carried them?

Colonel ERNST. Yes, sir.

Senator MORGAN. Would not that interrupt your conclusions and the satisfaction you would have in relying upon them in regard to building a dam at Bohio?

Colonel ERNST. No, sir.

Senator MORGAN. On what plan would you build a dam at Bohio as it has now been revealed?

Colonel ERNST. There are various methods, Senator, of tightening up that subfoundation. I think probably the most simple and economical

form would be to pump down liquid cement and turn that gravel into a concrete in situ.

Senator MORGAN. Has any great dam been built on that principle?

Colonel ERNST. Oh, yes, sir. They have done that on the Nile; not to such depths as that, but they have done it to a depth of 40 or 50 feet.

Senator MORGAN. They have done it to a depth of 40 or 50 feet; but they have got a granite foundation under the depth of the Assuan dam?

Colonel ERNST. Yes; but it is not that dam that I am referring to. It is the Assiut dam where they have done what I speak of. That dam that you speak of is all masonry, entirely built on a rock foundation.

Senator MORGAN. You still adhere to the belief that it is possible to build a permanent dam at Bohio?

Colonel ERNST. Yes, sir; I do.

Senator MORGAN. If that is possible, is not Bohio a better site than Gatun?

Colonel ERNST. No; I do not think it is.

Senator MORGAN. With a ridge coming in from each side and the spillway at Gigante?

Colonel ERNST. There is where the trouble about foundation comes in—about the length of the locks. We planned locks 740 feet long. Now the proposition is to build them 900 feet long.

Senator MORGAN. Is not the ground at Bohio sufficient for a 900-foot lock?

Colonel ERNST. No, sir.

Senator MORGAN. The ridge is not wide enough?

Colonel ERNST. No, sir.

Senator MORGAN. If we still found that a 750-foot lock was all that we needed, Bohio would still be, I suppose, the best location?

Colonel ERNST. I am not prepared to say that exactly. I like this lake navigation. It might possibly be still a better location, but I am rather inclined to think the Gatun location is the better one, because it gives more lake navigation.

Senator MORGAN. If you can get the lake navigation and maintain it, probably it is so; but are there no difficulties about constructing that dam at Gatun that you would like to avoid?

Colonel ERNST. It is a very big thing. No, sir; I do not think there are any difficulties that need trouble us.

Senator MORGAN. There is a gulch there 280 and odd feet deep; I forget exactly the depth—

Senator KITTREDGE. Two hundred and fifty-eight feet, as far as they have gone.

Senator MORGAN. Yes; 258 feet deep as far as they have bored down into that sugar-loaf gulch; and that is filled up, we will assume, and we have a right to assume it on the testimony, with permeable material; and then, opposite to that, on the same axis of the dam, there is another gulch that is about—how many feet deep is that other large, wide gulch? 200 feet?

Senator DRYDEN. Two hundred and four feet, I think.

Senator KITTREDGE. Yes; 204 feet.

Senator MORGAN. And that is filled up with permeable material. The indurated rock or clay which formerly filled these gulches, or which is supposed to have formerly filled them, has been washed out

and left an island in there. The dam, however, stretches right across both of them and across the island. Now is it, to your mind, any safer to build that great dam across these two gulches than it would be to build a dam across the same permeable material at Bohio?

Colonel ERNST. Oh, I do not think it is any safer; no, sir. The material which you speak of as permeable is only a small portion at the bottom; that is, that very loose material, the lower 50 feet of it. The upper 200 feet is practically impermeable; it is finer material. I am speaking now of the Gatun site. We have not found any material down there at all as coarse as some of that found at Bohio.

Senator MORGAN. They found wood there, did they not?

Colonel ERNST. Yes, I know they have found wood.

Senator MORGAN. Of course that is coarse material, and permeable, too?

Colonel ERNST. Yes; I meant gravel.

Senator KITTREDGE. May I ask a question here, Senator?

Senator MORGAN. Certainly.

Senator KITTREDGE. Colonel Ernst, you testified before this committee four or five years ago, did you not?

Colonel ERNST. Yes, sir.

Senator KITTREDGE. Upon the question of the foundation for the Bohio dam?

Colonel ERNST. Yes, sir.

Senator KITTREDGE. I read from page 676 of that testimony a question by the Chairman, Senator Morgan, at that time, referring to the pressure of the 85 or 90 foot head of water. He asked [reading]:

"The CHAIRMAN. That would be a tremendous pressure to put beneath a clay dam with material that is pervious to water?"

"Colonel ERNST. Oh, yes.

"The CHAIRMAN. It would be a very dangerous one, too.

"Colonel ERNST. Yes; unless you make that foundation tight, it is a dangerous one."

Senator MORGAN. That is the very point I had in mind, and I want to know from Colonel Ernst what his plan would be, now, for making that foundation tight down through this depth of 258 feet?

Colonel ERNST. Well, Senator, the claim is that it is practically tight now. What I said as to Bohio is strictly true. It did not apply only to the method which was suggested in that plan, but it applied to various other methods which might be used. If this lower 50 feet should by some wonder of nature discharge a large volume of water, it would be possible to reach that by this pumping process; but I do not believe it is going to be needed at all. There is this blanket, 200 feet thick, of impermeable material, covering it, and the amount of water that can get out under there is infinitesimal. That is what I think about it. I think that it will undoubtedly hold water.

Senator MORGAN. The higher you raise the head of water the more danger there is of its finding its way through permeable material at the bottom of the dam?

Colonel ERNST. Oh, yes; certainly.

Senator MORGAN. That is a danger that you can not take care of if the water goes through at all. You can not take care of it and reduce it to a mere seep or leak or percolation by building on top of it?

Colonel ERNST. I do not think the weight added on top will make very much difference about it. I think it will be impermeable with-

out it; practically impermeable. The amount of water that can leak through there is so small that it is not going to be appreciable at all.

Senator MORGAN. I do not look at it in the view of the wastage of the water, but the danger of the structure being undermined and sinking and breaking away.

Colonel ERNST. I do not think it is possible to get up velocity in there that would move any material at all. I think that is utterly impossible any more than the sandstone filter that they use in Spanish countries is worn by the water that flows through it. The velocity is so small that it can not have any wearing effect or transporting effect.

Senator MORGAN. No borings that have passed across the axis of the Gatun dam have actually reached rock foundation, unless you call this indurated clay rock?

Colonel ERNST. We call that rock.

Senator MORGAN. But you have not reached any such rock foundation as you found at Bohio? That was live rock—sure enough rock?

Colonel ERNST. I do not remember about that. It turned out that we did not get rock at all there, you know. My impression is that it was pretty much the same thing—hard material; a pipe would not sink any farther.

Senator MORGAN. But it still has not been hard enough to resist the action of water washing these great gulches out through it on each side around that island?

Colonel ERNST. That is true.

Senator MORGAN. If that is true, then it is not hard enough to resist a great current of water. But the rock at the bottom of the Bohio dam was hard enough to resist any pressure of water?

Colonel ERNST. I do not know about the relative hardness, Senator, at all.

Senator MORGAN. You have not seen Mr. Wallace's borings?

Colonel ERNST. Yes, sir; I have seen those.

Senator MORGAN. Did he get into the rock after he passed through those bowlders that stopped your augurs?

Colonel ERNST. I believe he did; yes.

Senator MORGAN. Do not those borings indicate that that is tough, hard rock?

Colonel ERNST. I do not think it is what you would call very hard rock. It is rock, but I do not think it is very hard rock.

Senator MORGAN. Is it basalt?

Colonel ERNST. No, sir; there is no basalt there.

Senator MORGAN. What would be the classification of it?

Colonel ERNST. I think it is a sandstone. They call it "Gamboa grit;" the French called it that, I believe.

Senator MORGAN. It is something a little peculiar to the location, then?

Colonel ERNST. Yes, sir.

Senator MORGAN. A conglomerate, probably, formed by—

Colonel ERNST. I presume it is the same that is in that Bohio quarry. It looks like sandstone, and I believe it is. It is very soft at first, but hardens. They build their bridge piers out of it. It makes fairly good building stone.

Senator MORGAN. Colonel, you have been a long time examining this Isthmus?

Colonel ERNST. Yes, sir.

Senator MORGAN. You have probably given as much personal attention to it as any man that has ever been there, have you not?

Colonel ERNST. Perhaps so.

Senator MORGAN. Do you know of the existence of any extinct volcanoes on the Isthmus out in the vicinity of the line of the canal?

Colonel ERNST. No, sir; I do not know of any?

Senator MORGAN. Down below Ancon Hill and out in that direction?

Colonel ERNST. I do not know of any. They may be there, but I do not know of any.

Senator MORGAN. My inquiry is based upon the fact Bunau-Varilla denies that there ever were any, and some of the witnesses on a former occasion before this committee swore that they had been down in them. I did not know but what you might have been?

Colonel ERNST. No, sir; I never have been.

Senator MORGAN. That is a difficult country to find anything in, is it not? It is covered with the chaparral, or a growth there, so that it is very difficult to find anything, is it not?

Colonel ERNST. Very.

Senator MORGAN. It is difficult even to find a great vortex in the ground, or a hill that rises above the ground, is it not?

Colonel ERNST. Very difficult.

Senator MORGAN. So that if a man testifies that he has seen extinct volcanoes there and been down in them, he would be more apt to know than a man that had passed by and did not see them?

Colonel ERNST. Oh, yes, sir.

Senator MORGAN. What difficulties are there, if there are any, within your knowledge, of an engineering sort or a physical sort in dredging a sea-level canal from the 40-foot contour through the Bay of Limon up as far as Gamboa?

Colonel ERNST. Only the difficulties of quantity and cost and of time. That is all.

Senator MORGAN. As to the cost, I suppose the transportation of the soil would be one of the big elements of cost?

Colonel ERNST. Yes, sir.

Senator MORGAN. Would not that be as cheap or cheaper by being carried out on barges to the sea and dumped into the sea wherever you might want to put it than it would be to haul it out on railroad tracks?

Colonel ERNST. The actual transportation of any particular cubic yard would be; yes, sir.

Senator MORGAN. The unit of cost of transportation of the material that you take out of a sea-level canal would be lower for transportation than it would be taken out dry and hauled off on a railroad?

Colonel ERNST. Yes; the idea I had in mind was that you would have a very narrow point of attack if you were attempting to use water transportation. You could only use water transportation over such portions of the canal as had water in it.

Senator MORGAN. If you came in from the 40-foot contour, your dredges would be followed by the depth of water, which would be 40 feet deep below sea level?

Colonel ERNST. Certainly, but you would be attacking just the front edge.

Senator MORGAN. That would be true on both sides of the Isthmus?

Colonel ERNST. Yes.

Senator MORGAN. So that there could be no want of water in conducting the dredging process right against the front of the opposing wall, whatever it might be, with the water following behind?

Colonel ERNST. Yes; but you could only use 2 or 3 machines, for instance, instead of 100, as they talk about using.

Senator MORGAN. But if the two or three machines could do the work of a hundred, it would make no difference, would it?

Colonel ERNST. No, sir.

Senator MORGAN. I think it is probably confessed that a dredge can do more work than a steam shovel, no matter how big it is, if the dredge is big enough.

Colonel ERNST. I suppose that is so.

Senator MORGAN. So that as an implement of work, in dredging or opening up a channel, the dredge is the preferable instrument, other things being equal, size and strength, etc.?

Colonel ERNST. Yes.

Senator MORGAN. If you were dredging a sea-level canal from the 40-foot contour to Gamboa, have you a sufficient knowledge of the topography at Gamboa and in that vicinity, between that and Bohio, to say whether you would follow the line of the River Chagres, or whether you would cut upon the right bank of the Chagres?

Colonel ERNST. Oh, yes; you could not follow the line of the Chagres River.

Senator MORGAN. You could not?

Colonel ERNST. No, sir; it is too tortuous. You would have to cross it a great many times.

Senator MORGAN. I mean, of course, the general line of the Chagres Valley.

Colonel ERNST. You would keep in the bottom of that valley, certainly.

Senator MORGAN. You would prefer to take your canal as straight as you could make it right across the river wherever you encountered it, but along the valley, rather than to encroach upon the hills on the right bank?

Colonel ERNST. Yes, sir.

Senator MORGAN. Is there any difficulty, in your estimation, in dredging a sea-level canal from this 40-foot contour up to Gamboa or the vicinity of it? Is there any physical obstacle there?

Colonel ERNST. Only the difficulty of getting it done in any reasonable length of time. You would have a very narrow point of attack. You could not, as you would if you were using land transportation, attack it at a great many different points—along, we will say, the whole length of the canal. By the method you describe you could only be attacking it at one point—the width of the canal in front.

Senator MORGAN. You would have two points: one from each side of the Isthmus?

Colonel ERNST. Certainly.

Senator MORGAN. And you could attack it with as many dredges as was necessary to cover the whole front of your operations?

Colonel ERNST. Yes, sir.

Senator MORGAN. Is there any physical obstruction or difficulty in the way of that?

Colonel ERNST. I do not know of any at all.

Senator MORGAN. At Gamboa you encounter the rock at the level of the sea?

Colonel ERNST. Yes, sir.

Senator MORGAN. How far is that rock beneath the topographic surface there?

Colonel ERNST. About 50 feet. The ground is about 50 feet above the level of the sea, I think.

Senator MORGAN. So that, after digging down for 50 feet, you would strike rock that was at the level of the sea, and you would have to go through that 40 feet below the level of the sea?

Colonel ERNST. Yes, sir.

Senator MORGAN. That would be 90 feet. Do you know of any physical or engineering difficulty that would be an obstruction—what we would call an obstruction—to the cutting of a sea-level canal along the line I have mentioned to Gamboa or in that vicinity? Would you find any impediment there that an engineer would shrink from and say "I can not accomplish it?"

Colonel ERNST. No, sir; there is nothing that is impracticable there.

Senator MORGAN. Between Gamboa and Obispo is about 3 miles, is it not?

Colonel ERNST. Yes, sir.

Senator MORGAN. We speak of the little village of Obispo—

Colonel ERNST. I think it is a little more than that. I can tell you in a moment. [After inspecting map.] It is 14 miles.

Senator KITTREDGE. You misunderstood the question. You are referring to Bohio there.

Senator MORGAN. You are referring to Bohio, are you not?

Colonel ERNST. Yes, sir.

Senator MORGAN. From Gamboa to Obispo, I mean.

Colonel ERNST. It is half a mile there—a very short distance. I do not believe it is more than half a mile.

Senator MORGAN. So that they are practically one location, speaking in the general sense. There is no special elevation or abrupt elevation of land between Gamboa and Obispo, is there?

Colonel ERNST. No, sir; there is not. The river comes in there. The rivers unite. The point between the rivers is very high ground. The Obispo River comes down and joins the Chagres River very near there.

Senator MORGAN. Yes.

Colonel ERNST. And of course they are at the same level where they join.

Senator MORGAN. Yes. And then there is a little valley through which the Obispo runs to join the Chagres?

Colonel ERNST. Yes, sir.

Senator MORGAN. And the canal would go right up that little valley?

Colonel ERNST. Yes, sir.

Senator MORGAN. Is the ground abrupt and high on either side of it?

Colonel ERNST. Yes, sir.

Senator MORGAN. Particularly so?

Colonel ERNST. Yes, sir; there is where you approach the Culebra Cut. That is the beginning of it.

Senator MORGAN. That is the first approach you make toward the Culebra Cut?

Colonel ERNST. Yes, sir; that is what you may call the beginning of the Culebra Cut.

Senator MORGAN. You go up the Obispo River from Gamboa, and then you go into the hill at the proper angle, called the first Emperador, and then Culebra?

Colonel ERNST. Yes, sir.

Senator MORGAN. Then your work is through that ridge, and from that over to Miraflores?

Colonel ERNST. Yes, sir.

Senator MORGAN. Have you ever examined the plan of the dam that the majority of the consulting engineers propose to put in at Gamboa?

Colonel ERNST. They did not prepare any plan, Senator; they submitted no design for that dam.

Senator MORGAN. They submitted no design?

Colonel ERNST. No design at all. They described it as an all-masonry dam or an earth dam with a masonry core; but there is no design for it.

Senator MORGAN. They give the height of it?

Colonel ERNST. Yes, sir; but no design.

Senator MORGAN. And an indefinite length upstream?

Colonel ERNST. That is all they say. They give the height.

Senator MORGAN. They do not give a cross section of it, do they?

Colonel ERNST. No, sir; they give no design at all.

Senator MORGAN. In your studies of this country, which I have no doubt have been entirely profound and very careful, what is your view or your opinion as to the practicability of putting a dam at Gamboa of the height that the majority of the committee propose?

Colonel ERNST. I believe it is practicable to build it.

Senator MORGAN. About how high is that?

Colonel ERNST. One hundred and eighty feet.

Senator MORGAN. That would throw the water back beyond Alhajuela probably?

Colonel ERNST. Yes, sir.

Senator MORGAN. I believe they give measurements for that as to the size of the lake it would form?

Colonel ERNST. Yes, sir.

Senator MORGAN. As to the cubic contents of the lake?

Colonel ERNST. Yes; they do give that, too.

Senator MORGAN. Would the water impounded by such a dam as that be sufficient to fill the prism of a canal between, say, Obispo and Miraflores?

Colonel ERNST. I have not in mind what that volume is, Senator, but I should think it would.

Senator MORGAN. On the other side, if a sea-level canal is dredged in from the 40-foot contour, near these islands, I suppose that would be through the level country, the low country, to Miraflores, and if that canal should be 40 feet deep below the level of the sea, and, say, 300 feet wide, would a canal with a prism of those dimensions dispense with the necessity of putting in a sea-gate?

Colonel ERNST. I do not think it would.

Senator MORGAN. Why?

Colonel ERNST. I think the volume of water that is to go in there has got to get through somehow—you mean for a sea-level canal?

Senator MORGAN. I mean a sea-level canal, yes, with a rise of water 10 feet or 10½ feet above ordinary sea level at high tide.

Colonel ERNST. That is one of those problems that is not capable of definite solution; but I made some such study as this, if it interests you at all [illustrating by pencil sketch]. We will suppose that this represents the Panama end of the canal, and this the Colon end. This distance is 47 miles, that height is 10 feet, and that height 10 feet [indicating]. Supposing the slope to be uniform all the way from Panama to Colon, which is the most favorable condition that you can have for velocities—that involves filling into that canal a prism of water which is shown there [indicating]. That can be computed. I have computed it.

The velocity required to get that volume of water in there is greater than you can possibly get up on that slope, which shows to me that that tidal influence will not extend clear over to Colon. It will only extend a little less than halfway. That gives you a slope which can be computed, and from that I get a velocity of 5 or 6 feet a second for an average. It is not going to be the same at all times. There can not be any average velocity there. It will be much greater at one time than it will be at another time; but I should expect a velocity of 6 or 7 feet a second there at least.

Senator MORGAN. At high tide?

Colonel ERNST. Yes, sir; at high tide and at low tide. It would flow in at one time and flow out at the other time.

Senator MORGAN. So that you think that that would not dispense with the necessity for the sea gates, even if that canal is 300 feet wide?

Colonel ERNST. No, sir; I think we will have to have sea gates there still.

Senator MORGAN. Suppose you make it 400 feet wide?

Colonel ERNST. I do not know where the limit will come. I suppose it would come in time, but not with a width of 400 feet. I think you would still have to have the sea gates with a width of 400 feet.

Senator MORGAN. I called your attention to it because some of the engineers who have appeared before the committee have said that a canal with a prism of 300 feet extending from Miraflores out to the sea would dispense with the necessity for the sea gates.

Colonel ERNST. That is a surmise, for which they can not give any convincing proof.

Senator MORGAN. A sea-level canal there would be 40 feet below sea-level according to the project, would be 200 feet wide, I believe it is, and the rock as developed by the borings through the Culebra Heights would average, according to some estimates that have been made here, 25 feet above sea-level; and that rock is all described, after you have reached it and until you get through it, as a solid cube of rock, of course with dikes in it and fissures and one thing and another; but, practically, in operations and in work it would be estimated as a solid cube. It would be, then, 65 feet in depth, 200 feet wide, and 8 miles long. That would be about the size of it, would it not?

Colonel ERNST. Yes, sir.

Senator MORGAN. It would take a long time and a great deal of hard work to get that cube of rock out of there, would it not?

Colonel ERNST. Yes, sir; a great deal.

Senator MORGAN. Was that one of the deterrents against the construction of the sea-level canal?

Colonel ERNST. Yes, sir.

Senator MORGAN. On account of the time it would take and the money it would cost?

Colonel ERNST. Yes, sir.

Senator MORGAN. Did any of the engineers suppose it would be otherwise impracticable?

Colonel ERNST. No, sir.

Senator MORGAN. In an engineering sense?

Colonel ERNST. No, sir; none at all.

Senator MORGAN. They thought that rock could be taken out?

Colonel ERNST. Oh, yes.

Senator MORGAN. The two plans that were submitted were a lock canal and a sea-level canal; that is to say, a lock canal over the whole width of the Isthmus, in some form, and a sea-level canal through the whole width, in some form, with practically the same line, the same curvatures, and all that. Was any intermediate plan ever suggested or acted upon by the Commission?

Colonel ERNST. You mean our commission of 1901?

Senator MORGAN. I mean the board of consulting engineers.

Colonel ERNST. They studied three or four different projects, different arrangements of dams.

Senator MORGAN. But they were all either lock canals through and through, or else they were sea-level canals through and through?

Colonel ERNST. Yes, sir.

Senator MORGAN. And an intermediate plan of a canal partly sea-level and partly a lock canal across the Culebra Heights was not passed upon by them?

Colonel ERNST. No, sir; unless you call that part leading up to Gatun, between Colon and Gatun, a sea-level canal. It is at the level of the sea.

Senator MORGAN. Yes; from Gatun up to Colon, or out to sea?

Colonel ERNST. Yes.

Senator MORGAN. That would be a sea-level canal.

Colonel ERNST. There is about 7 miles of it there.

Senator MORGAN. That would be, necessarily, a sea-level canal—that much of it?

Colonel ERNST. Yes.

Senator MORGAN. The two propositions that were submitted to the consulting board, as I understand, upon which they passed, were the lock canal, practically covering the whole width of the Isthmus, or a sea-level canal covering the same width.

Colonel ERNST. Yes, sir.

Senator MORGAN. But the question of the possibility of an intermediate plan of which, say, two-thirds would be sea-level and one-third lock canal was not considered?

Colonel ERNST. They considered a number of things, but I am not quite familiar with what they were. They made a number of studies besides. I think they discussed that.

Senator MORGAN. But they did not pass upon any such proposition as I suggest, because it was not submitted to them?

Colonel ERNST. No, sir; it never was worked up in detail.

Senator MORGAN. That was their duty, or what they were invited to do—to pass upon the simple question of a lock canal over all or a sea-level canal over all, across the Isthmus? The other projects, or

studies, whatever they may have been, were not passed upon except for the purpose of making calculations and the like of that?

Colonel ERNST. Yes, sir.

Senator MORGAN. Would you consider that a canal that was a sea-level canal as far out as from the 40-foot contour to Gamboa and then, say, a 60-foot level, if you please, from there across to Miraflores, and then return to the sea-level structure from that out to the Panama Bay, say, to the Isle of Naos, or wherever it might reach the 40-foot contour—would you consider that an impracticable scheme?

Colonel ERNST. No, sir; I think that could be done. You mean physically practicable?

Senator MORGAN. Physically practicable, yes.

Colonel ERNST. Yes; I think so.

Senator MORGAN. In that case you would get the water to fill that prism between Gamboa and Miraflores out of this Gamboa dam?

Colonel ERNST. Yes.

Senator MORGAN. And your opinion is that the stream there would furnish enough water to fill that prism, the balance of the proposed prism being, of course, filled with sea water?

Colonel ERNST. Yes, sir.

Senator MORGAN. That is all I want to ask you, Colonel.

Senator KITTREDGE. Do you regard the conditions at Bobio as favorable for the construction of a dam as at Gatun, leaving out of consideration the question of locks and the securing of a greater supply of water?

Colonel ERNST. Yes; I do. It would be a shorter dam.

Senator KITTREDGE. And you regard the conditions under the surface as favorable as at Gatun?

Colonel ERNST. Well, yes; I think I may say that. They are certainly conditions that can be met without any difficulty at all. Engineering resources can close up that subfoundation.

Senator KITTREDGE. You make that statement in the light of the fact that since you have testified here before, under the direction of Mr. Wallace, borings have gone 40 feet deeper than they had at that time?

Colonel ERNST. Oh, yes. That would not change my idea about the feasibility of building that dam at all.

Senator KITTREDGE. I will read just a few questions and answers from your testimony given before the committee four or five years ago, at the time Senator Morgan was chairman of the committee. (Reading:)

“The CHAIRMAN. So that there are contingencies to be looked forward to of serious character, both in the temporary dam and in the permanent dam?

“Colonel ERNST. I should think so.

“The CHAIRMAN. Do you agree with Mr. Morison that 125 feet below sea level at Bobio is an unusual and extraordinary depth in which to do pneumatic work?

“Colonel ERNST. Well, it never has been done yet to that depth.

“The CHAIRMAN. Do you know that it ever has been attempted, but failed?

“Colonel ERNST. No, sir.

“The CHAIRMAN. Well, engineers have not as yet been heroic enough to undertake it.

"Colonel ERNST. I do not know whether it requires heroism or not. They have not done it.

"The CHAIRMAN. If you were at work for private owners, who had to furnish the money out of their own pockets, you would despair of convincing them that it was a good venture.

"Colonel ERNST. It would depend on the necessity for it. Of course you take chances where you have to do it, and you do not take them where you do not have to."

Do you agree with that statement to-day?

Colonel ERNST. Oh, yes, sir; entirely. May I read the paragraph to which that examination referred in the report?

Senator KITTREDGE. You mean of the testimony?

Colonel ERNST. Not the testimony, but the report of the Commission.

Senator KITTREDGE. The testimony, of course, referred to the dam at Bohio?

Colonel ERNST. I want to read you what I had already signed concerning that dam. This was a sequel. It covers about a page. Do you object to that length of quotation?

Senator KITTREDGE. Refer to the page from which you read.

Senator MORGAN. I think it had better go in.

The CHAIRMAN. Read it, Colonel.

Colonel ERNST. It is an extract from the report of the Isthmian Canal Commission of 1899-1901 (reading from pages 94 and 95):

"The Bohio dam is the most important structure on the line, being of great magnitude, of vital necessity to the scheme, and offering many difficulties of construction. The Commission has devoted much time to the procurement of full and reliable information concerning the foundation upon which this dam must rest and to a study of the various types of structures which might be adopted." Then it gives an account of the borings and the materials.

"These materials are found in beds of varying shape and thickness, not distributed with uniformity, and not arranged according to any general law from which can be deduced the character of the soil at points other than those actually examined. In every section constructed from the borings strata of greater or less dimensions are found, which are permeable by water. How far these extend and whether or not they communicate with the surface of the ground above the site of the dam are points about which information can not be obtained in advance with certainty. If a dam be built with permeable strata under it there will probably be leakage, but what the amount of this will be is a question about which there is room for much difference of opinion.

"It would seem probable to many that the leakage will not be sufficient to endanger the water supply and that an earthen dam is therefore feasible, but it is evident that here is a danger to be avoided if possible. A masonry dam founded throughout upon the rock or an earth dam with a masonry core going down everywhere to rock would close the valley completely and would leave no question open as to its future efficiency. In its preliminary report the Commission based its estimates on a masonry dam. The examinations of the ground had not at that time been completed. So far as they had progressed they showed a site where a masonry dam seemed the most suitable, but it was subsequently found that the depth to rock upon that site was at least 143 feet below sea level at the deepest part.

"It was considered best to avoid, if possible, so great a depth of foundation. A site was found a few hundred feet farther downstream, where the length of the dam would be considerably greater than at the former site, but the greatest depth to rock revealed by the borings was only 128 feet below sea level. The line runs from a point near the railroad station at Bohio, on the east side of the river, straight across to the rocky hill on the west side.

"On the east side the rock is at the surface practically from the water in the river to the end of the dam. On the west side the bank above low water is composed either of pure clay or of clay mixed with sand, while below low water are found irregular beds of sand and sandy clay. The physical features of the location admit of the construction of an earth embankment with a heavy masonry core carried down to bed rock throughout the length of the structure. For reasons of economy that type of dam is preferable to one wholly of masonry upon the new site, and is now adopted."

So that it was to remove all doubt. There is something else here in my evidence before that committee that I would like to find.

Senator KITTREDGE. Right at that point, if it will not interrupt you: The dam of which you were talking when you testified before us at the time I have mentioned, four or five years ago, contemplated a foundation to bed rock, did it not, at Bohio?

Colonel ERNST. That was the scheme on which the estimate was made. It did not mean, necessarily, that there was no other way to make that subfoundation tight. The point was to make the subfoundation tight.

Senator KITTREDGE. You recommended to us, or advised, at least, that the dam at Bohio be placed upon a rock foundation?

Colonel ERNST. Yes; the core.

Senator KITTREDGE. Yes; either on a foundation of solid rock or a masonry core. That is right, is it not?

Colonel ERNST. Yes, sir.

Senator KITTREDGE. You regarded that dam at Bohio without a masonry core—putting it that way—as involving danger to the structure and danger to the canal, did you not?

Colonel ERNST. No, sir; that is not a necessary sequence. Let me read you some more of this evidence of which you have already quoted a part (reading):

"Senator HANNA. Now, about the Bohio dam. That is a matter about which there has been a great diversity of opinion in the testimony given here, and I would like to have your opinion about the construction of that dam—as to whether or not is feasible. The two dams have been discussed. Mr. Morison gave testimony that, in his judgment, he thought that upon further examination that in the work of construction he had faith to believe that a core dam would not be necessary.

"Colonel ERNST. That is the opinion of many very sound engineers.

"The CHAIRMAN. Have you seen Mr. Morison's statement in his paper before the American Society of Engineers?

"Colonel ERNST. Yes; I have seen that. These French engineers did not propose to put a core down at all. They did not know how far the rock was—they did not find it. We did. They proposed an earth dam and Mr. Morison prefers an earth dam. The majority of the Commission felt that that left a danger that it was desirable to avoid

if possible. There is no use of taking unnecessary risks, and we thought it was possible to close that geological valley absolutely, with an impervious core, going down to bed rock, and then there is no question but what there is under that dam an impervious core. That was the most conservative way, at least for the estimate, but at the same time a very much more expensive way, and the Commission felt that it was desirable to put in an estimate for the most effective and the most expensive dam.

"Senator HANNA. But when it came to the time for construction and further investigation conditions may be found to exist that would change the opinion in reference to that?"

"Colonel ERNST. That is possible.

"Senator HANNA. And, of course, there would be further investigations made before any work would be commenced?"

"Colonel ERNST. Yes."

Senator KITTREDGE. That was the testimony that I had in mind. So that you regarded that condition which you have described there as a danger to the dam structure and the canal itself, did you not?

Colonel ERNST. We regarded the leakage under the dam as a danger; yes. We did not regard that masonry core as a necessary means to stop that leakage. There were other means to stop it.

Senator MORGAN. But still you recommended a cut-stone dam?

Colonel ERNST. No, sir; an earth dam with a masonry core.

Senator MORGAN. Did the Commission recommend an earth dam with a masonry core?

Colonel ERNST. Yes, sir. What we were trying to do there was to give a thing that was absolutely safe.

Senator KITTREDGE. That is the wise thing to do always in a work of this sort, is it not?

Colonel ERNST. Exactly. The masonry core was one method. It was to be put down by the pneumatic process. It was not the only method.

Senator KITTREDGE. What other methods had you in mind at that time, and have you in mind now, to cut off that water?

Colonel ERNST. The principal method, the one that I should first use, would be to pump down liquid cement.

Senator KITTREDGE. To what depth can that be done?

Colonel ERNST. I do not see why it can not go to any depth that you can put a pipe down.

Senator KITTREDGE. Is there certainty that you can by that method effectually close all places through which water percolates?

Colonel ERNST. I think so.

Senator KITTREDGE. How can you determine that fact absolutely?

Colonel ERNST. Why, you can have test pipes and see when the flow stops. I think it is perfectly feasible to tighten up all those crevices, so that there will not be any leakage at all.

Senator KITTREDGE. Do you advise that that method be pursued in the Gatun dam structure?

Colonel ERNST. No, sir; I do not think it is necessary there at all. It is one of the things that could be done if it were necessary.

Senator MORGAN. That liquid cement when it was pressed into the interstices of a material that it was to harden would unite with such material and make a grouting that would make a solid rock in the course of time?

Colonel ERNST. That is just what it would make.

Senator MORGAN. If there was any wood in there it would not unite, would it?

Colonel ERNST. It would be buried in this artificial rock. It would make an artificial rock, and anything there would be buried in it.

Senator MORGAN. It would be very necessary, would it not, Colonel, to have the material into which you make this injection of cement of such consistency and such uniformity of structure as that the cement would fill up all parts of it under pressure, so that when it hardened it would become equivalent to solid rock there?

Colonel ERNST. You would want to fill up all the interstices; yes, sir.

Senator MORGAN. You would do that by putting pressure enough upon your pump to drive it down?

Colonel ERNST. Yes, sir.

Senator MORGAN. I want to ask the Colonel some other questions on a different subject.

Senator KITTREDGE. I wish to ask him one more question, if I may, Senator?

Senator MORGAN. Certainly.

Senator KITTREDGE. Why do you recommend that this process which you have described be used at Bohio and not at Gatun?

Colonel ERNST. There is a very great difference in the material down there near the bottom. At Bohio we found some material there as big as a hen's egg. We did not find it, but Mr. Wallace's borings found material down there as big as a hen's egg. They have no such material as that at Gatun. That is the reason.

Senator KITTREDGE. In what respect does the material differ taken from the borings at Bohio and at Gatun, at the depth of 258 feet?

Colonel ERNST. In that respect. In one case it is fine and in the other case it is not. It is very much finer and very much less porous in the one case than in the other.

Senator KITTREDGE. But at Gatun it is porous just the same, is it not?

Colonel ERNST. Not the same; no.

Senator KITTREDGE. But it is porous?

Colonel ERNST. Yes; there is some porous material down at the bottom.

Senator KITTREDGE. Differing only in degree?

Colonel ERNST. Only in degree; yes.

Senator MORGAN. But the report of the minority does not propose to inject cement down into these deep gorges?

Colonel ERNST. No; I do not propose it either. You do not understand me to propose it?

Senator MORGAN. You merely recommend it as a measure that——

Colonel ERNST. That could be used at Bohio. We are talking about the Bohio dam, entirely.

Senator MORGAN. Could you not make use of the same material, in the same way, at Gatun?

Colonel ERNST. Certainly, if you wanted to; if it was necessary.

Senator MORGAN. In case you did it by injecting cement, you would have a better foundation, or a better stone protection against percolation of water than you would have at Gatun?

Colonel ERNST. Yes, sir.

Senator MORGAN. Because the material is finer?

Colonel ERNST. It would be better. It is not necessary.

Senator MORGAN. You are a member of what I call the Walker Exploration Commission of 1901?

Colonel ERNST. Yes, sir.

Senator MORGAN. And you served on that and joined in the report?

Colonel ERNST. Yes, sir.

Senator MORGAN. And then you became a member of the first Walker Construction Commission?

Colonel ERNST. No, sir; I was not a member of that.

Senator MORGAN. Or of the present one?

Colonel ERNST. I am on the present one.

Senator MORGAN. You were not with the Walker Commission, then, when they were encountering the first work that they had to do in providing for constructing the canal down there?

Colonel ERNST. No, sir.

Senator MORGAN. But you knew the conditions pretty well, did you not?

Colonel ERNST. Yes, sir.

Senator MORGAN. I wish you would describe them, Colonel, if you please. I want to show, in justice to that Commission, the sort of work that had to be done and the amount of it in the first opening up of their work on the canal.

Colonel ERNST. The work had gone to seed. The French had a force down there of 600 or 700 men taking care of the property. There was an immense amount of machinery and plant of every description upon the site, which we had looked over and pronounced worthless; that is to say, it was so nearly worthless that we would not make any special allowance for it. It is said to have cost \$30,000,000, and I think that is not impossible.

There were village after village of these laborers' camps, engineering camps along the Isthmus, some of them buried in thickets. Some of them you would not know were there, and they were not discovered until later. Those buildings looked a great deal worse than they really turned out to be afterwards. The exterior was badly rotten, the boards were exposed to the weather, wind, and rain, and were ready to fall to pieces. You would take those off, and you would come to good lumber; so that there was a good deal more in the buildings than we thought there was.

The railroad was overworked and behind the times. There was a man in charge of it who had left this country sixteen years before, who was a very good railroad man in his day, but who had not learned anything of the new methods. The wharves were not sufficient really for the every day traffic of that railroad. The Commission had to create everything from the ground. They had to rebuild or build new all the structures required for a population, we will say, of 25,000 people; and by that I do not mean simply boarding houses and sleeping rooms, but they had to build jails, and hospitals, and court-houses, and everything else that you require in a municipality.

They had to multiply the wharf room by eight or ten—I do not know what—to build new wharves. They had to buy new steamers to get things down there. This could not all go on at once, because to do this work you had to have shelter for your men, and they did not have that. So that the progress had to be gradual, of course, first getting a little more force, and then a little more accommodation to take

care of more force; so that it increased by degrees. It was utterly impossible to do that thing in a day—absolutely impossible. I think the Commission did some very good work down there.

Senator MORGAN. Then they had to organize transportation, I suppose, on the Isthmus?

Colonel ERNST. Yes, sir. They had to reorganize the railroad, and they had to get a new plant. The locomotives were out of date and the cars were out of date. I think they ordered some 1,500 cars. I have a memorandum of that somewhere. [Consulting memorandum]. Yes; they ordered 24 locomotives, 500 box cars, 6 passenger cars, 12 caboose cars, 1 pile driver and wrecker for the railroad.

Senator MORGAN. This was all necessary just for inaugurating the work?

Colonel ERNST. For inaugurating it, yes, sir. They ordered 61 steam shovels, 120 locomotives, 1,300 flat cars, 324 dump cars, 12 Lidgerwood unloaders, and 13 spreaders. Those were some of the principal items of plant that they had to get. Concerning that old material down there, as I say, we were not willing to allow anything for it. We were conscious that there was some residue of value in it; that some of that material might be used—bar iron, and things like that, surveying instruments, and so on—but we were not ready to pay anything for it at all, except in that general item of omissions. That is all they had. They patched up a lot of that and kept their force going with it.

Senator MORGAN. The railroad and connecting steamers that belonged to the railroad were an indispensable arm of that service?

Colonel ERNST. Yes, sir; absolutely.

Senator MORGAN. But for those they could not have made any progress?

Colonel ERNST. Practically, no.

Senator MORGAN. If they had depended upon miscellaneous shipping to get their material and people in there, and food, and all that, they could have made practically no progress.

Colonel ERNST. No, sir.

Senator MORGAN. The country was barren of food, practically?

Colonel ERNST. Yes, sir; there was not enough for the people who lived in it.

Senator MORGAN. The railroad was then, in fact, and practically during the first year of the effort to open that canal, the most active and the most important factor in the work?

Colonel ERNST. Yes, sir.

Senator MORGAN. Who controlled that railroad in regard, for instance, to transportation, and also in regard to freight rates across the Isthmus at that time? Was it the railroad company?

Colonel ERNST. The railroad company, yes; the board of directors.

Senator MORGAN. When you got there as a commissioner you found that the railroad and all of its work and all of its property and all of its possessions were under the control of the railroad company?

Colonel ERNST. Yes, sir.

Senator MORGAN. Through a board of directors?

Colonel ERNST. Yes, sir.

Senator MORGAN. And the United States had acquired at the time you became a Commissioner all or nearly all of the stock in the railroad?

Colonel ERNST. Yes, sir.

Senator MORGAN. And soon acquired the whole of it?

Colonel ERNST. Yes, sir.

Senator MORGAN. And the United States, through its Canal Commissioners, organized a board of directors for that railroad with some outsiders coming in—stockholders?

Colonel ERNST. Yes; the number is fixed by law—by the charter—and the Secretary of War really represents the Government. He dictates the board of directors.

Senator MORGAN. He dictates—or did then, when you first came in, dictate—the majority of the board of directors; but there were still persons who were elected in some way by the stockholders that had not as yet sold their stock?

Colonel ERNST. I do not understand it that way, Senator. The shares were so few and so scattered that they could not control a director. There were only some 1,100 shares, and they were scattered all over the world. The other nearly 69,000 were voted by the Secretary of War, and he dictated the board of directors; and he ordered that each member of the Canal Commission should be a member of the board of directors.

Senator MORGAN. Yes; that is, controlling the majority of the stock?

Colonel ERNST. Yes, sir.

Senator MORGAN. So that after the Government took over the property it first obtained a board of directors, and they were really named and elected by the stock of the United States?

Colonel ERNST. Yes, sir.

Senator MORGAN. And through the Secretary of War?

Colonel ERNST. Yes, sir.

Senator MORGAN. And the Secretary of War went out and got other persons who had no connection with the construction of the canal at all, and no interest in it, to come in and constitute membership in that board?

Colonel ERNST. Yes, sir.

Senator MORGAN. You had been there at the opening and before the opening of any work done by the United States Government, and you arrived again, I suppose, as a Commissioner, at the time that the first Commission was removed.

Colonel ERNST. Yes, sir; soon after that.

Senator MORGAN. Do you know whether their resignation had been required by the Government?

Colonel ERNST. Not of my personal knowledge. I only know what I saw in the newspapers about it.

Senator MORGAN. But they had all resigned?

Colonel ERNST. Yes, sir.

Senator MORGAN. And a new Commission was appointed?

Colonel ERNST. Yes, sir.

Senator MORGAN. And upon that new Commission some of the old Commissioners were retained. Who were they? Colonel Hains was one that was retained, was he not?

Colonel ERNST. No, sir; Colonel Hains was on the Commission of 1899-1901. He was not on the first construction Commission. There was no member of it retained—yes; Major Harrod was retained.

Senator MORGAN. Was he the only one?

Colonel ERNST. Yes, sir.

Senator MORGAN. So that six were removed or resigned, and one remained?

Colonel ERNST. Yes, sir.

Senator MORGAN. And he formed a nucleus around which the new board was assembled?

Colonel ERNST. Yes, sir.

Senator MORGAN. Where is Major Harrod now?

Colonel ERNST. He is here in the room. [Laughter.]

Senator MORGAN. He is right here? I did not know the gentleman. I did not know that he was in the room.

When you entered upon your duties as a commissioner, you then first knew accurately the amount of work that had been done by that first construction commission?

Colonel ERNST. Yes, sir.

Senator MORGAN. Did you think that was a creditable or a discreditable performance on the part of that board?

Colonel ERNST. It certainly was not a discreditable one.

Senator MORGAN. Have you any knowledge of any objection that was urged by the President or by anybody else to a member of that first construction commission, called the Walker commission, on the ground of incompetency or delinquency in the performance of duty or for any other cause?

Colonel ERNST. No, sir.

Senator MORGAN. There was nothing assigned?

Colonel ERNST. No, sir; I never heard of anything.

Senator MORGAN. They were merely swept out and a new commission put in. Have you any knowledge of the influences that were brought to bear—any of them—to produce that result?

Colonel ERNST. No, sir.

Senator MORGAN. Were you surprised at it?

Colonel ERNST. Very much.

Senator MORGAN. You were very much surprised?

Colonel ERNST. Yes, sir.

Senator MORGAN. You are still unable to account for it?

Colonel ERNST. Yes sir; entirely.

Senator MORGAN. The country seems to be in the same condition. When you entered upon work there under the new Commission, did the Commission immediately go down to the Isthmus, after they were appointed and organized?

Colonel ERNST. Not immediately. We were organized the first of April, and the order of the President was that we should meet on the Isthmus the first of each quarter; that is, the first of April, the first of July, and so on. We were organized too late to go at that time, so that we, under the orders, intended to go in June. Mr. Wallace's resignation came just about the time that we were getting ready to go down there, and that deferred the trip for two or three weeks, so that we did not actually go until some time in July.

Senator MORGAN. How long did you remain on the Isthmus after you went down as a body?

Colonel ERNST. I think we were there about two weeks.

Senator MORGAN. When you got there you found that the previous Commission had organized all of the statutes and ordinances that were necessary for the government of that Zone, or supposed to be necessary?

Colonel ERNST. Yes, sir.

Senator MORGAN. That was a heavy task, was it not?

Colonel ERNST. I should think it must have been a very heavy task.

Senator MORGAN. The records here show that it must have been a heavy task. And they had put in operation the judicial establishment, organized and put in operation the health establishment, and the labor as far as it was being conducted, and the commissary establishment, and whatever was necessary for the accommodation of the laborers who were there and those that were coming in. I suppose that is all correct, that they had done all that?

Colonel ERNST. They had done it as far as they were able to do it. Of course that work was not completed.

Senator MORGAN. The laborers came in rapidly after the new Commission was appointed, did they not?

Colonel ERNST. Yes, sir.

Senator MORGAN. You made it a business to push labor in there, employees of every kind?

Colonel ERNST. Yes, sir.

Senator MORGAN. And a good many appointments were made to clerical and other positions among what were called the gold men?

Colonel ERNST. Yes, sir.

Senator MORGAN. And there were some thousands added to the list of laborers?

Colonel ERNST. Yes, sir.

Senator MORGAN. About how many?

Colonel ERNST. I think that that force grew from about 7,000 in July to some 17,000—I do not know, Senator.

Senator MORGAN. That was an addition practically of 10,000 laborers?

Colonel ERNST. There was a very large addition, I know that.

Senator MORGAN. The first Commission had put on, I suppose, from your calculations here, about five or six thousand laborers?

Colonel ERNST. Oh, I think so.

Senator MORGAN. And then, when the new Commission came in, there were 10,000 more put on.

Colonel ERNST. There have been that many added; yes.

Senator MORGAN. And it was done in a hurry, was it not—with rapidity?

Colonel ERNST. As fast as we could; yes, sir.

Senator MORGAN. You made great efforts to get labor?

Colonel ERNST. Yes, sir.

Senator MORGAN. When this great addition of 10,000 laborers came into this Isthmus, were sufficient quarters provided for that great addition to the force?

Colonel ERNST. There was always a tight squeeze. There were always more men than there were quarters, and I suppose that is so to-day; but the quarters were being increased as fast as they could, and the men were being increased as fast as the quarters could be provided, and the thing kept along in that way.

Senator MORGAN. And there were rapid importations I suppose—and the record shows it—of lumber for building material from the Pacific coast and from the Atlantic coast?

Colonel ERNST. Yes, sir.

Senator MORGAN. And of all other kinds of material that were necessary to be employed in the rapid progress of the work?

Colonel ERNST. Yes, sir.

Senator MORGAN. And you had a great many mechanics there, carpenters, and so on, for the purpose of putting up houses and repairing houses, etc.?

Colonel ERNST. Yes, sir.

Senator MORGAN. And the work went on rapidly?

Colonel ERNST. Yes, sir.

Senator MORGAN. And hurriedly. You then added water to provide for those people?

Colonel ERNST. Yes, sir.

Senator MORGAN. And to provide a water supply for Panama?

Colonel ERNST. Yes, sir.

Senator MORGAN. And also for Colon?

Colonel ERNST. Yes, sir.

Senator MORGAN. Had the old commission made progress in furnishing a water supply for these places?

Colonel ERNST. Oh, yes, sir.

Senator MORGAN. They had pretty nearly completed it, had they not?

Colonel ERNST. They had the water turned on at Panama, which was the most important of all of the water supplies. They had brought their pipes down from the reservoir into the city and had laid, I think, 25 per cent of the pipes in the city and had turned the water on. There were public hydrants and some of the houses were supplied. But all the people could go out to the hydrants and get water at the time we went there.

Senator MORGAN. That water supply came from a distance of 6 or 7 miles?

Colonel ERNST. Yes, sir.

Senator MORGAN. Out of the reservoir that the old Commission had constructed there in the hills?

Colonel ERNST. Yes, sir.

Senator MORGAN. And they got the water chiefly, I suppose, out of the Rio Grande or its affluents?

Colonel ERNST. At the headwaters of the Rio Grande they formed the reservoir.

Senator MORGAN. Was the water usable and good?

Colonel ERNST. It seemed to be very good, indeed.

Senator MORGAN. Well, then, this first Commission had also put in additional wharfage?

Colonel ERNST. Yes; but I do not think any of it was finished. They had begun it.

Senator MORGAN. Had they made improvements upon the railroad?

Colonel ERNST. Yes; they had made some improvements.

Senator MORGAN. Had they extended any spur tracks into the diggings?

Colonel ERNST. I can not be sure about that. Have you our annual report here?

Senator MORGAN. I would not detain you to go over that, because it is, perhaps, not a very important item.

Colonel ERNST. They had made some improvements in the railroad. They will be found enumerated in our annual report.

Senator MORGAN. Down in the Bay of Panama, did they make any necessary improvements in order to facilitate commerce in connection with ships?

Colonel ERNST. Well, they had a dredge at work there.

Senator MORGAN. They had a dredge at work?

Colonel ERNST. Yes, sir; they had a dredge at work, and they had overhauled the repair shop there for making marine repairs.

Senator MORGAN. That was down at La Boca, at the mouth of the Rio Grande?

Colonel ERNST. Yes, sir.

Senator MORGAN. And they had overhauled and repaired other machine shops along on the line of the railroad and the canal, down clear to Colon?

Colonel ERNST. Yes, sir.

Senator MORGAN. Had they made repairs in Colon, and made any effort to clean up that place?

Colonel ERNST. Well, they had not done any engineering. They had begun on their water supply. Yes; they had cleaned all the American part.

Senator MORGAN. As to the condition of the engineering when you took over these French maps, was it at all satisfactory, in regard to projected work that the Commissioners had in view? Were those maps satisfactory? Were they either reliable or sufficiently developed?

Colonel ERNST. They were very reliable where the French had actually done work. The French are excellent engineers, and wherever these maps were the result of actual observation they were very reliable; but there was more or less sketching in some parts of those maps.

Senator MORGAN. Take the maps topographically, reaching out into the headwaters of the Chagres and the other rivers, were those maps reliable?

Colonel ERNST. In many places they were not, because, as I say, they were not the result of actual observation, they were sketches.

Senator MORGAN. Was it not necessary to predicate your work in the canal upon a resurvey of the whole system from end to end?

Colonel ERNST. No, sir; I could not say that, Senator. The line of the canal was very thoroughly surveyed, and anything within easy reach of the canal, anything that would come anywhere near the canal prism itself. When we would come to overflowing large tracts of country by dams such as the Gamboa dam or any other dam, there you would get back into country that was not very well known, and there was where the trouble came in.

Senator MORGAN. As to the line of the canal: Take its axis through and through; had the French conducted borings along the entire line of that canal from Colon out to the Bay of Panama?

Colonel ERNST. Yes, sir.

Senator MORGAN. So as to get down to the actual condition of the substratum, as deep as sea level?

Colonel ERNST. Yes, sir; they had.

Senator MORGAN. Were those borings reliable?

Colonel ERNST. Yes, sir.

Senator MORGAN. Were they close enough together to give sufficient accuracy to the data?

Colonel ERNST. They were reasonably so. Of course, we have made a great many since; and the more borings you have the better. It is impossible to make enough borings to give anything more than

a general idea, anyway. Yes, I think you may say they were reasonably close together.

Senator MORGAN. Do you know whether the Joint Commission relied upon the French borings at all, or whether they took the American borings as furnishing the proper data for determining what was below the surface?

Colonel ERNST. I do not know about that; but I presume they took the latest; I do not know how much attention they gave to that French profile.

Senator MORGAN. As a practical business matter, with your present knowledge of what those engineering reports and maps and contributions to literature, and so forth, were, would you give \$2,000,000 for lars for them?

Colonel ERNST. Yes, sir.

Senator MORGAN. You would?

Colonel ERNST. I would.

Senator MORGAN. And yet would not rely upon them after you got them?

Colonel ERNST. I would try to make some fair compensation for what they cost.

Senator MORGAN. I am not talking about that, but just as if you had no idea of compensation about it and were getting them at a fair price for what they were worth to the incoming Engineering Corps of the United States.

Colonel ERNST. I do not believe you could have gotten that information for \$2,000,000, Senator.

Senator MORGAN. You do not think you could have gotten the information that the French had there for \$2,000,000?

Colonel ERNST. No, sir; I do not believe you could have made all those surveys and constructed all those maps for \$2,000,000, and of course you could not have gotten the history. The records would go back for twenty or thirty years. You could not get that at all at any price.

Senator MORGAN. Is there much use for that history?

Colonel ERNST. Yes, sir; that is what we rely on to determine what the action of the Chagres River will be in the future.

Senator MORGAN. That includes the measurements of the flow of water in the river?

Colonel ERNST. Yes; the flow of the water in the river is changing all the time, and is different in different years, and we have a fairly decent record of it now for about fifty years; only fair, though. If we had it a hundred years back we would be a good deal more sure of it.

Senator MORGAN. In that respect I suppose what the French wrote was a mere account of the operation of the water gauges that they put in the Chagres River and watched? That is all?

Colonel ERNST. Their original observations, yes; and they collected all the information that they could collect, also.

Senator MORGAN. That was not any intricate engineering project or process?

Colonel ERNST. That is not costly except in the matter of time. It does not cost much to make those observations.

Senator MORGAN. Is there any point, or was there any point when you went to survey that Isthmus as a Commissioner and looked over

what had been done or remained to be done, in which you found that the former Commission had been deficient in industry, perseverance, knowledge, or fidelity?

Colonel ERNST. No, sir; none at all.

Senator MORGAN. None at all?

Colonel ERNST. No, sir.

Senator MORGAN. And you still do not know the reason why they were removed?

Colonel ERNST. No; I do not know of my own personal knowledge. I have seen everything that has been published in the newspapers.

Senator MORGAN. The newspapers are not always reliable upon such subjects, are they?

Colonel ERNST. No; I may say that I do not know.

Senator MORGAN. You may have formed some opinions, but you got them from newspaper accounts?

Colonel ERNST. Exactly.

Senator MORGAN. Practically—looking over the ground and surveying it with a view to continuing that work that had been commenced there—you found no deficiencies and no mistakes?

Colonel ERNST. Oh, I do not mean to say that I saw no mistakes, but no more than any man is liable to make. Any man is liable to make mistakes. I do not think there were any very grave mistakes except, possibly, one. No; I do not think that there were any grave mistakes.

Senator MORGAN. Have you in mind any mistake that you would call such without attributing to it any great gravity or weight?

Colonel ERNST. I have in mind a mistake which has had serious results, but I do not know but that it is a mistake that any man might have fallen into.

Senator MORGAN. I would like you to mention it.

Colonel ERNST. I think the conclusions drawn from the experimental work done in Culebra was a mistake that had bad results.

Senator MORGAN. What was that?

Colonel ERNST. That you could take that material out for 50 cents a yard.

Senator MORGAN. That was too cheap?

Colonel ERNST. Yes; I think so, decidedly.

Senator MORGAN. It was too cheap by a dollar, was it not?

Colonel ERNST. No, sir; by 30 cents, at least.

Senator MORGAN. The first commission estimated that you could take out that material through Culebra cut at 30 cents?

Colonel ERNST. No, sir; they estimated that you could take it out at 80 cents. You asked me what mistakes I noticed. The new Commission, or at least the engineering committee of the new Commission, thought they could take it out for 50 cents.

Senator MORGAN. That the others had priced it too high?

Colonel ERNST. Yes; they thought so.

Senator MORGAN. Mr. Wallace, who conducted that work, found that he sometimes had to pay \$1.75 per cubic yard for it.

Colonel ERNST. Well, that developed afterwards. Mr. Wallace thought he could take it out for 50 cents. I think he testified that before this committee at the hearing. I think he is mistaken.

Senator MORGAN. What is the unit of price that you would put upon the dry work to be done through from Gamboa to Miraflores?

Colonel ERNST. Well, for that material in there it is about 80 cents. Our estimates are 80 cents for soft rock in the dry, \$1.15 for hard rock in the dry, and then we had another estimate of \$4.75 for rock under water. I think they were not far out of the way.

Senator MORGAN. Are you prepared now to recommend those estimates as being such as the Government can act upon?

Colonel ERNST. I think you might reduce the rock-under-water estimate somewhat. That is the most uncertain item in the whole matter. I think those other figures are about right. They are essentially what have been adopted by this Consulting Board.

Senator MORGAN. Was any of the spoil that was hauled out by the work done by the first Commission left where it has to be worked over a second time?

Colonel ERNST. I do not know of any such case at all.

Senator MORGAN. Do you think any mistake was made in selecting the dumps for the spoil?

Colonel ERNST. No, sir; I do not think so.

Senator MORGAN. So that the work done by them would bear scientific tests?

Colonel ERNST. I think so.

Senator MORGAN. I do not know that I have any further questions to ask.

Senator ANKENY. Colonel, have you any idea what area of land that dam in the lock system would overflow; that is, how much land it would destroy? In other words, how much damage this Government would be liable for in the event that lock system was completed?

Colonel ERNST. Yes; I have some idea. I think it is 105 square miles that that large lake overflows and some 8 square miles for that one. This is the principal one up here [indicating on the map]. I think 58 square miles of that is now owned by the railroad or the canal, and the remainder is either private property or owned by the Panama Government. A great deal of it is marsh. The marshes are shown on this other map perhaps better than they are on this one. There is a good deal of marsh down here [indicating]. You have had some extraordinary evidence given before the committee about the value of this land.

Here is all this marsh that is overflowed now [indicating on map]. So is this. This is half overflowed [indicating]. But of course there will be a good deal of land flowed. It is almost uninhabited, except right along the line of the railroad. There are a number of little villages on the line of the railroad, but I think nearly all of that property belongs to the railroad. The estimates that have been given you of \$18,000,000—and one man said, I think, \$25,000,000—seem to be preposterous.

Senator ANKENY. What would be your idea? You are familiar with the whole subject.

Colonel ERNST. I do not see why that estimate of the minority is not about right. They say \$300,000. The Chief Engineer, Mr. Stevens, looked into that question, and independently reached that same figure without knowing at all how the other party reached it.

Senator ANKENY. How do you know what belongs to the railroad and what belongs to the citizens there?

Colonel ERNST. Well, we have a land map.

Senator ANKENY. Certainly; but what titles?

Colonel ERNST. The titles are somewhat mixed, I believe.

Senator ANKENY. You do not know?

Colonel ERNST. No; I do not know.

Senator TALIAFERRO. Colonel, do you know of any person in this country who was a stockholder or a bondholder in the first Panama Canal Company—the French company?

Colonel ERNST. No; I do not.

Senator TALIAFERRO. There were American stockholders, were there not?

Colonel ERNST. I suppose so. I do not know.

Senator DRYDEN. Have you an opinion, Colonel, as to whether this work should be constructed as it has been by day work or by contract?

Colonel ERNST. Oh, I think clearly that we ought to let out contracts. I do not think there is any difference of opinion about that.

Senator DRYDEN. Is it your view that it should be let in separate contracts or in one entire contract?

Colonel ERNST. I should not undertake to give it in one entire contract. I would divide it up into a number of large contracts. I would not have a very great number of small contracts. I would have a lot of large contracts.

Senator DRYDEN. Do you think that we have to-day sufficient information for the bases of specifications for contracting this work?

Colonel ERNST. I think so, yes; for most of it. There is some further information that would be desired about some features of it.

Senator DRYDEN. What information, if any, is lacking for the bases of such specifications?

Colonel ERNST. Well, I should want some further examinations made—and they are being made, too—about this overflow of that spillway [indicating on map]. This plan provides for a spillway through the dam, and up here [indicating on map] there is an opportunity, perhaps, for another spillway entirely detached from that. There is some low ground in there [indicating on map.] That river runs up here, and this runs up here [indicating], and Mr. Stevens is now engaged on that. He is boring in there and examining in there to see whether we can not make a little improvement on that. So that we should want to go into detail a little more than we have.

Senator DRYDEN. If I am not mistaken, some of the engineers who have testified here have said in effect that in constructing this canal there ought to be leeway allowed for additional light or new discoveries that might be made from time to time as to what should be done. Do you concur in that opinion?

Colonel ERNST. I do; yes, sir.

Senator DRYDEN. Then, would it not result if that is so in rendering it necessary to make new arrangements to some extent with the contractors after the work had been undertaken?

Colonel ERNST. If you let out one contract for the whole job it would; yes. I would not do it that way. I would let out a contract for, we will say, one set of these locks, and another contract for another set of locks, and I would let out a contract for dredging the coastal plane from Limon Bay up to Gatun. That is one class of work separate entirely from lock construction. I would let out another contract over at the other end if we should put that lock at Miraflores as the Secretary of War recommended, and so on. You could divide

that work up into—oh, I do not know how many, but I suppose a dozen large contracts. Each in itself would be a very large contract.

Senator DRYDEN. If you did that, how would you protect the Government against the delays, the expense, and other disadvantages that might arise from the clash of the contractors.

Colonel ERNST. I do not know—

Senator DRYDEN (continuing). As to where the authority and rights of one began and the other ended?

Colonel ERNST. That would have to be definitely known, of course.

Senator DRYDEN. You can see that difficulty can you not?

Colonel ERNST. Yes; it is a thing that has to be guarded against, of course.

Senator DRYDEN. Do you think that you could prepare specifications of such a general character that they would sufficiently guard the interests of the Government and yet when they came to be applied in details would be sufficient to hold the contractor?

Colonel ERNST. Well, I should hope so. I think it would be possible; yes, sir.

Senator MORGAN. If he had a pretty large deposit or bond put up as a guarantee for good behavior—you would have that much, would you not?

Colonel ERNST. Yes, sir. Of course there is going to be great difficulty in dividing up the facilities that we have there—the railroad and the wharves and all that sort of thing; but I think it could be handled.

Senator DRYDEN. In an ordinary commercial enterprise, where the work is done by contract, you are quite aware, no doubt, that almost invariably there are alterations as the work progresses?

Colonel ERNST. Oh, yes.

Senator DRYDEN. Changes in the plans, and consequently in the specifications, which involve new arrangements, rearrangements with the contractor?

Colonel ERNST. Certainly.

Senator DRYDEN. And the contractor generally has the owner at a disadvantage in those matters. Now, in a big work of this kind, could the Government be amply and sufficiently protected against any imposition on the part of the contractors?

Colonel ERNST. I should think so. It seems to me it is possible.

Senator DRYDEN. Of course you recognize that that would be a very important matter?

Colonel ERNST. A very important matter.

Senator DRYDEN. It might make a difference of many millions of dollars in the course of building the canal as to whether the specifications protected the Government or not?

Colonel ERNST. Oh, yes, sir; the payments would probably be so much a cubic yard or so much a unit of volume, whatever it may be, concrete or whatever it is, and the contractor would be paid for what he actually did. It would hardly be necessary, I should think, to make any such radical changes as would change—

Senator MORGAN. The unit of value would account for all additions to the work that might be omitted from the specifications?

Colonel ERNST. You would provide for that.

Senator MORGAN. I say, the unit of value would provide for all additions that might be made to the specifications?

Colonel ERNST. Certainly.

Senator MORGAN. And where changes were made that same unit of value would be a fair test of the added cost or the reduced cost?

Colonel ERNST. I can hardly conceive of letting the contract before you have made up your mind about such general features as that that I have just referred to, that new location for a spillway. That, of course, would involve a great deal of change in the unit price. If you get your material out at that place, it might cost very differently from what it would at Gatun. I would not let any contract until I had made up my mind about such general features as that, as to whether to move it over there or not. I do not see why, having the general outline fixed with a reasonable degree of closeness—

Senator MORGAN. I will ask you the question whether, in your opinion, work to be done by the Government in building this great structure would not, as a rule, be more expensive and more wasteful and harder to direct than if it was done by contract?

Colonel ERNST. Oh, I think that there are very great advantages in doing it by contract. You not only have a very close figure, but you have the advantage of bringing in the contractor's clientele, his crowd, his people. The Government never could get them in any other way at all. Nearly all of these contractors have a set of men that they know, and who know them, and who have been working for them all their lives. They would bring them right into the Government service, and the Government can not get them in any other way. I think there are great advantages in letting out contracts. I do not see any reason why a Government officer in a work on a moderate scale would not do it as well as anybody else, but he has not got the people to carry on a work of this magnitude.

Senator MORGAN. The work done up to date by the Government has been pretty expensive?

Colonel ERNST. Some of it has been; and some of it has been very economical.

Senator DRYDEN. In a contract, of course you could bind the contractor as to the quality of work, as to the cost of the work, founded upon some unit price, and also as to the time of completion?

Colonel ERNST. Yes, sir.

Senator DRYDEN. That, of course, would be a great advantage.

Senator MORGAN. You can control the time by contract.

Senator KITTREDGE. Why do you regard it as advisable to seek another location for a spillway?

Colonel ERNST. I am not sure that it is advisable to do it, but we want to look into that.

Senator KITTREDGE. Where is the spillway located under the present plan?

Colonel ERNST. In that hill between the two branches of the dam. The dam crosses two gulches, you know.

Senator KITTREDGE. Is it in the hill?

Colonel ERNST. Yes, sir.

Senator MORGAN. It is cut right through the hill.

Senator KITTREDGE. In what way is it connected with the Gatun dam?

Colonel ERNST. Well, the Gatun dam consists of two parts, you may say, one on each side of this hill, and this spillway is cut right through the natural ground of the hill.

Senator KITTREDGE. And what is the size of the hill downstream?

Colonel ERNST. I do not think I quite understand the question.

Senator KITTREDGE. What is the width of the hill downstream?

Colonel ERNST. It depends entirely on where you take it.

Senator KITTREDGE. Where the spillway is.

Colonel ERNST. Well, the width of the hill would depend on where you take it. At the crest it is nothing.

Senator KITTREDGE. How did you take it when you located the spillway?

Colonel ERNST. I did not locate it. I can not answer that question, Senator.

Senator KITTREDGE. Do you not know where, with reference to the hill, the spillway is located?

Colonel ERNST. Right in the middle of the hill. Right through the hill.

Senator KITTREDGE. What is the length through the hill, downstream?

Colonel ERNST. Measured on the spillway?

Senator KITTREDGE. Yes.

Colonel ERNST. I do not know. I shall have to refer to drawings for that.

Senator KITTREDGE. Can you ascertain it handily?

Colonel ERNST. I do not know whether it is shown in these maps or not. Of course the thickness of the hill depends upon what level you take it at. The hill is a cone, changing its dimensions at every height.

Senator KITTREDGE. The spillway is near the top of the water level.

Senator MORGAN. That would be about 80 feet, then?

Senator KITTREDGE. About. As I recollect, that is the height of it. I want to know what distance you travel before you run out of the hill?

Colonel ERNST. The bottom of that spillway is at an elevation of 70 feet. The thickness of the hill at elevation 70 would be an answer to your question, would it?

Senator KITTREDGE. Is that the height of the spillway?

Colonel ERNST. Yes; the bottom of it. The spillway has a lip over which the water flows, and there are gates sliding up and down above it—

Senator KITTREDGE. I understand what a spillway is.

Colonel ERNST. The height of this lip is 70 feet.

Senator MORGAN. That would make the water 15 feet deep on the spillway.

Colonel ERNST. It is closed by gates which slide up and down and enlarge or diminish the size of the opening. The bottom of that is at an elevation of 70 feet. The thickness of the hill at 70 feet is, as nearly as I can make it out, here on this map, 100 feet.

Senator KITTREDGE. One hundred feet through the hill?

Colonel ERNST. Yes; at that level.

Senator KITTREDGE. Then how is the spillway constructed after you leave the hill?

Colonel ERNST. Oh, it is sunk clear down into the hill. I thought you asked me the thickness of the hill at the crest of the spillway. Perhaps I can show you better on this section. That is the form of it [indicating on section]. This is earth; this is concrete. There is the crest of the spillway, right there [indicating], and above it are these sliding gates; and the thickness of the hill at that level is 100 feet.

Senator KITTREDGE. How do you control the water in the spillway after it passes the hill?

Colonel ERNST. It flows down over here [indicating on section].

Senator KITTREDGE. In what sort of a structure?

Colonel ERNST. This is concrete—all masonry. It spills over into a triangular-shaped basin, like that, and slides down and is collected and carried off through a channel into the Chagres River.

Senator KITTREDGE. What sort of a basin do you have there?

Colonel ERNST. Concrete; artificial stone.

Senator KITTREDGE. How far is that basin within the limits of the dam up and down stream?

Colonel ERNST. It does not come in the dam at all, Senator; it is in this hill. There is the outline of it, there [indicating on map].

Senator KITTREDGE. Back of the hill, then?

Colonel ERNST. It is right through the hill.

Senator KITTREDGE. Downstream from the hill the two wings of the dam do not touch; is that it?

Colonel ERNST. That is it.

Senator KITTREDGE. How far apart are they?

Colonel ERNST. They are represented right here [indicating on map]. There is the hill; here is the dam, and on this side that slopes down here and slopes that way and this way [indicating on map].

Senator KITTREDGE. In what manner is the water kept from the sides of the dam after leaving the hill structure?

Colonel ERNST. It is carried off in a masonry conduit.

Senator KITTREDGE. To what distance is it constructed of masonry?

Colonel ERNST. That would depend on the site. That is shown here. I should say several thousand feet. It is not defined. That will depend entirely on the necessities of the case at the time of construction.

Senator KITTREDGE. Have not plans been worked out for that?

Colonel ERNST. Not in any more detail than this. This is all that I have, what was furnished by the consulting board.

Senator MORGAN. One question about that hill. That is a sort of sugar-loaf elevation, is it not?

Colonel ERNST. Yes, sir.

Senator MORGAN. Do those things occur frequently in the coastal plane of Panama down there, those uplifts, or sugar-loaf hills?

Colonel ERNST. Yes, sir; there are a good many of them around there.

Senator MORGAN. They are isolated—not connected together by ridges?

Colonel ERNST. Not necessarily; no.

Senator MORGAN. Are they of volcanic origin?

Colonel ERNST. I presume so, originally.

Senator MORGAN. They were thrown up at different places along on that coastal plane by volcanic action?

Colonel ERNST. That I do not know, Senator, whether they were or not.

Senator MORGAN. Have you ever dug into one of them or had them examined to see what their structure was—whether it was rock?

Colonel ERNST. Only these borings. They have gone into a great many of them and they find them to be what they have nicknamed indurated clay, which does not seem to be a very good name.

Senator MORGAN. That means volcanic ash lifted up and compressed afterwards until it was united into hard material?

Colonel ERNST. I really do not know.

Senator ANKENY. You said that you preferred the small contracts; that you thought they were preferable. What is your objection to letting it in one contract, if you could find a person who would take it?

Colonel ERNST. I can not see any way that you can get any competition in letting such a contract as that.

Senator ANKENY. If that were possible and such a contract could be made, one contract for the greater portion of the work, say east or west of that big cut, what is your objection to letting it in one big contract? You say that there would be confusion and embarrassment with small contractors; might not that be obviated by letting the work to a greater contractor? You have given your objections without telling us the remedy.

Colonel ERNST. I do not think I gave that as an objection, Senator. I simply said it was one of the difficulties. I think I said distinctly that that is what I would do.

Senator ANKENY. Let it in small contracts?

Colonel ERNST. Yes, sir; not in small contracts, but a number of contracts.

Senator ANKENY. Twelve or more, you said?

Colonel ERNST. Something like that.

Senator ANKENY. Why do you object to a large one?

Colonel ERNST. I should anticipate very great difficulty in letting any such contract as that. I do not see exactly where you would get any competition. I do not see but what you would have to bind yourselves completely in advance as to every detail.

Senator ANKENY. There is the same objection to a small contract, is there not?

Colonel ERNST. Not to so great an extent. Those are my principal objections. I should think a contract like that, left to any syndicate, would be putting immense power into the hands of somebody that was not in the interest of the United States.

Senator ANKENY. That is your objection to letting it in large contracts?

Colonel ERNST. In one single contract, yes.

The CHAIRMAN. I believe that is all, Colonel Ernst, and we are very much obliged to you, sir.

(The committee thereupon adjourned until to-morrow, Tuesday, March 27, 1906, at 10.30 o'clock a. m.)

STATEMENT OF GEN. PETER C. HAINS,
U. S. ARMY,
BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Tuesday, March 27, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Hopkins, Ankeny, Morgan, Taliaferro, and Simmons.

STATEMENT OF BRIG. GEN. PETER C. HAINS, U. S. ARMY (RETIRED).

The CHAIRMAN. Please give your full name and residence, General.

General HAINS. Peter C. Hains; Washington, D. C.

The CHAIRMAN. And your military position, and your present duties?

General HAINS. At the present time I am a brigadier-general of the United States Army, on the retired list, and a member of the Isthmian Canal Commission.

The CHAIRMAN. You are an army engineer?

General HAINS. I have been an army engineer for about forty-two years. I am not an army engineer now.

The CHAIRMAN. You ought to be an army engineer by this time—a retired one.

General HAINS. No, sir; I was promoted to be a brigadier-general in the line.

The CHAIRMAN. Yes?

General HAINS. I was transferred from the engineers in April, 1903, to be a brigadier-general in the line.

The CHAIRMAN. Were you a member of the Walker Commission, the first Commission?

General HAINS. The Commission of 1899-1901; yes, sir.

Senator MORGAN. You are still on the active list, I believe?

General HAINS. No, sir; I have been retired.

The CHAIRMAN. You were a member of the committee that was sent down to the Isthmus in the fall, were you not; and you signed the minority report?

General HAINS. You mean in 1901?

The CHAIRMAN. No; at this time; this report.

General HAINS. This last report?

The CHAIRMAN. Yes.

General HAINS. Yes, sir.

The CHAIRMAN. General, we would like to have your judgment in regard to these two types of canal, if you will be kind enough to give it to the committee; your opinion in regard to the different types and why you prefer one over the other.

General HAINS. I have a memorandum here, Senator, of some reasons why I prefer the lock canal to the sea-level canal, and I will state them briefly and endeavor to elucidate some of the points that were treated only in a brief manner in our report. I think our report covers nearly everything that has any influence with me, but there are details about that—that is, there are matters in connection with some of the points that are not referred to in detail.

Senator MORGAN. What report do you refer to, General?

General HAINS. I mean this last report, submitting the two reports of the Consulting Board.

Senator MORGAN. Of the Consulting Board?

General HAINS. Yes, sir.

Senator MORGAN. You were with the minority on that report?

General HAINS. Yes, sir. Before doing that I would like to make one statement in regard to Professor Burr's testimony. General Ernst referred to it yesterday. Professor Burr states that the recommendation made by the Isthmian Canal Commission of 1901 was largely for the tentative purpose of making a comparison between the Nicaragua and the Panama routes. Of course I do not know anything about what controlled Professor Burr, whether he regarded our project as tentative or not, but I did not regard it as tentative.

Senator MORGAN. You speak now of the project for a dam at Bohio?

General HAINS. Yes, sir; the project that was submitted by the Commission of 1901.

Senator MORGAN. Yes; that is the Commission of exploration and examination?

General HAINS. Yes, sir; what you call the Commission of exploration; and we state in our report the reason why we rejected the sea-level canal, and we state it in this way, on page 88 of that report: "That this Commission concurs with the various French commissions which have preceded it since the failure of the old company in rejecting the sea-level plan, and while such a plan would be physically practicable, and might be adopted if no other solution were available, the difficulties of all kinds, and especially those of time and cost, would be so great that a canal with a summit level reached by locks is to be preferred."

That was my opinion at that time, and I supposed that that was practically the opinion of all the others, because we all signed it.

Senator MORGAN. That is your opinion yet?

General HAINS. That is my opinion still.

Senator KITTREDGE. Right at that point, General: The plans of the old French company were for a sea-level canal?

General HAINS. Yes, sir. You mean the first company?

Senator KITTREDGE. I mean the old De Lesseps company.

General HAINS. Yes, sir.

Senator KITTREDGE. And when was the change made?

General HAINS. The change was made after the failure of the De Lesseps company to complete that canal.

Senator KITTREDGE. And the organization of what is known as the New Panama Canal Company?

General HAINS. Yes, sir.

Senator MORGAN. No; I beg to call attention to the fact that the change was made while the receiver of the old company had charge of it and before the new company was organized.

General HAINS. Yes; the first commission or board was what was called the Comité d'Etudes.

Senator MORGAN. That was organized by the receiver?

General HAINS. By the receiver.

Senator MORGAN. And they recommended the change?

General HAINS. They recommended a lock canal.

Senator KITTREDGE. Why did they do that, General?

General HAINS. I think it is pretty hard to say what all of them may have had in their minds, and I do not know that I can answer for any of them.

Senator KITTREDGE. Was not the reason the fact that they became short of money?

General HAINS. I think, perhaps, that was one reason.

Senator KITTREDGE. Was not that the reason, and does it not so appear of record?

General HAINS. No, sir; not according to my understanding.

Senator KITTREDGE. What is your understanding of the situation?

General HAINS. My understanding was that they found that they had a more difficult problem before them, and they learned more about it, and it was advisable not to try to carry it on because it was going to cost too much for any private corporation to complete.

Senator KITTREDGE. Then, it was a question of cost?

General HAINS. Partially.

Senator KITTREDGE. Rather than of feasibility?

General HAINS. Well, no; I can not say that. I do not know what they had in their minds, but the question of cost doubtless was one of the reasons.

Senator KITTREDGE. Was it not the reason?

General HAINS. I do not understand that it was the only reason.

Senator TALIAFERRO. Were not the questions of cost and of time the reasons that influenced you to prefer the high-level canal?

General HAINS. Not entirely. Those are two principal reasons.

Senator KITTREDGE. The controlling reasons?

General HAINS. They are the strongest reasons.

Senator KITTREDGE. Are they controlling?

General HAINS. No, sir; they are not controlling; that is, they do not control it alone. There are other strong reasons.

Senator MORGAN. General, you have examined these maps that we took over from the French Canal Company?

General HAINS. Yes, sir.

Senator MORGAN. Have you found among those, from the beginning of the first operations upon the canal, any actual survey accompanied with borings that would take the work down to a sea-level canal?

General HAINS. Among those?

Senator MORGAN. Yes; actual surveys with borings?

General HAINS. They had a number of borings, Senator, that went down as deep as would be necessary for a sea-level canal, but not many.

Senator MORGAN. As deep as would be necessary for a sea-level canal down to the bottom of the canal prism?

General HAINS. I did not think they had enough to base a project on.

Senator MORGAN. Did De Lesseps while he was in charge of that work ever have a complete or sufficient instrumental survey with borings for the purpose of determining the practicability or the cost of a sea-level canal?

General HAINS. When they started on the work there they did not.

Senator MORGAN. Very good. When was the first approximation to such a thing as that attempted by the French engineers?

General HAINS. During the time the French were at work they began surveys.

Senator MORGAN. Yes.

General HAINS. And they continued them clear up to the time of the report, or somewhat near the time of the report of the technical committee in 1898.

Senator MORGAN. They began the survey and the work at the same time?

General HAINS. Yes, sir; I think so.

Senator MORGAN. The survey did not precede the works?

General HAINS. Well, they made examinations.

Senator MORGAN. I know, they made examinations, but I am talking about a thorough survey of location, cost, dimensions, and all that.

General HAINS. A thorough survey was not made until afterwards.

Senator MORGAN. Was a thorough survey made while the receiver had the property in charge, and before the organization of the New Panama Canal Company?

General HAINS. I can not answer that question positively, from my own knowledge, but I do not think they ever had sufficient surveys then.

Senator MORGAN. It was upon what was known by the engineers and reported by the engineers that the Comité d'Etudes predicated their decision under the auspices or authority of the receiver. The Comité d'Etudes did not make any surveys themselves?

General HAINS. I am not sure whether they made any surveys or not.

Senator MORGAN. I think I can assure you that there is no evidence that they ever did.

General HAINS. Yes.

Senator MORGAN. If that is so, then up to the time that this Comité d'Etudes made their recommendation in favor of a lock canal the sea-level plan had never been worked out or projected as an engineering scheme upon a working scale?

General HAINS. Well, I can not say that exactly, Senator. That may be so.

Senator MORGAN. When the New Panama Canal Company came in did they attempt even to make a survey for a sea-level canal?

General HAINS. I do not think they did. They decided to build a canal with locks.

Senator MORGAN. They adopted the recommendation of the Comité d'Etudes, and went on to work it out?

General HAINS. Yes, sir.

Senator MORGAN. And the Comité d'Etudes had projected a lock-level canal—a level at what height above the level of the sea?

General HAINS. They considered several levels. I do not remember now.

Senator MORGAN. It was 90 feet or 95 feet, or something like that?

General HAINS. I do not remember.

Senator MORGAN. It was a high level?

General HAINS. They considered various levels.

Senator MORGAN. It was a high level, one of the highest proposed by anybody except Bunau-Varilla.

In regard to surveying there and examining this matter under the exploration commission, then, you took, necessarily, the French surveys as the basis of your calculations. You did not have time to make any extended surveys?

General HAINS. You say the first surveys. We took all the surveys that the French had made.

Senator MORGAN. I say you took all that they had made.

General HAINS. Yes, sir.

Senator MORGAN. But you predicated your conclusions very largely and almost entirely upon French surveys, first and last?

General HAINS. Yes, sir.

Senator MORGAN. Then you added to that some borings at Bohio and some at Gatun?

General HAINS. Yes, sir.

Senator MORGAN. But you did not undertake to bore out the axis of the canal across to Panama?

General HAINS. No, sir.

Senator MORGAN. That was the situation in which the engineering stood at the time the committee of exploration under Walker examined and made their report to the President.

I merely wanted to bring those facts out, so that we could get the historical connection between the surveys.

Senator DRYDEN. Is that all that you wish to ask, Senator?

Senator MORGAN. That is all that I wanted to ask the General now.

Senator DRYDEN. I wanted to ask you a question. Referring back to your testimony of a few moments ago, you stated in effect that while you deemed the items of cost and time which would be involved in the construction of a sea-level canal as of importance, yet they were not controlling in your mind in leading you to the selection of the lock canal. Will you state what other reasons there were besides those of length of time and cost which led you to recommend a lock canal?

General HAINS. The engineering difficulties, partly; and the fact that I do not think the sea-level canal recommended by the consulting board is as good a canal as the other one.

Senator DRYDEN. Do you mean by that to state that if the two types of canal cost the same amount of money and would consume the same amount of time in construction you would still prefer the lock canal?

General HAINS. Well, I think I would still prefer the lock canal, even though the cost was about the same.

Senator DRYDEN. What other element or what other features would be involved, in your mind, in favor of the lock canal?

General HAINS. Well, Senator, there are various things, and I think if you will allow me to state them in the sequence in which I have them here perhaps I shall bring them out clearly to you.

Senator DRYDEN. In your own way, certainly.

Senator MORGAN. That question now brings out all the statements that he wishes to make.

The CHAIRMAN. You have a statement prepared, have you, General?

General HAINS. No, sir; I have not a statement. I have merely some notes here.

The CHAIRMAN. I think it would be well under the circumstances,

to let the General go ahead with his statement, and when he gets through we can question him.

Senator DRYDEN. Certainly.

General HAINS. I have made some notes here of points that I wish to bring to the attention of the committee.

The CHAIRMAN. Yes. Proceed and make your statement as you have it in your mind, and the members of the committee will then ask you a few questions later on.

General HAINS. In respect to the time: The part of the work that determines the time needed to construct the Panama Canal is the Culebra cut. This cut has a length of 13 kilometers (equal to about 8 miles), and the amount of material to be excavated from it for the sea-level plan is, according to the estimates based on the plans and sections of the advisory board, about 110,000,000 cubic yards.

Senator MORGAN. Let me ask you, right there: Between what points do you locate what you call the Culebra cut?

General HAINS. It is near Obispo; just above Obispo. It is along about here [indicating on map], right near Obispo. It is about 8 miles.

Senator MORGAN. To Miraflores?

General HAINS. Not as far as Miraflores, but about to Pedro Miguel. There is 8 miles [indicating on map], and it is just about that distance. I could show you better from the profile.

Senator MORGAN. I do not care for the exact figures, but speaking generally it is between Obispo and Pedro Miguel?

General HAINS. Yes, sir. Of this amount of 110,000,000 cubic yards, 77,000,000 cubic yards is classed as rock, and of this rock more than 15,000,000 cubic yards is below the level of high tide in the Pacific Ocean. The depth of the cut from the natural surface on the axis of the canal is about 374 feet and the line of intersection of the slope of the cut with the slope of the ground at the highest point is over 600 feet. That would be about in here [indicating on map]. The old land came about like that [indicating].

Senator MORGAN. Do you mean as it is now, or as it will be?

General HAINS. No, sir; I mean originally.

Senator MORGAN. You mean, down to the bottom of the canal?

General HAINS. I mean the depth down to the level of the water would have been 370 feet.

Senator MORGAN. The ocean level?

General HAINS. Yes, sir.

Senator MORGAN. Then the canal would be 40 feet deeper than that, if it was constructed on the plan?

General HAINS. Yes, sir. And the line of intersection of the slope of the cut with the slope of the ground at the highest point is over 600 feet. A cut of this magnitude is without precedent. Nothing like it has ever been done, and that is another reason that led me to favor the lock canal.

Senator MORGAN. Do you mean the slope would be over 600 feet long?

General HAINS. Yes, sir.

Senator KITTREDGE. Is that the engineering difficulty that you mentioned?

General HAINS. That is one. If the material were equally distributed along the entire length of the cut the task of removing it, within

such limits of time and cost as will meet the reasonable expectations of the country, would be formidable.

Senator MORGAN. Right there let me ask you: You measure that slope at 600 feet; do you mean that takes it down to sea level, or below sea level?

General HAINS. That takes it down to sea level.

Senator MORGAN. It would be 640 feet, then, to the bottom of the canal, if the canal was 40 feet deep?

General HAINS. Yes, sir; it is about that. It is not exactly that. You can not tell just exactly where that land comes in. It is, you might say, somewhere about 600 feet.

Senator MORGAN. That is an estimate?

General HAINS. Yes, sir.

Nearly one-third of the entire amount, viz., about 32,000,000 cubic yards, is concentrated within the length of 2 kilometers, about $1\frac{1}{4}$ miles. The concentration of so much excavation within this limited space renders it impracticable to attack it simultaneously from many points. As a consequence, the time needed to complete this particular portion determines the time for completing the whole.

It is generally conceded that the surest and best method of excavating the Culebra Cut is by means of steam shovels or excavators, working, whenever practicable, in the dry and loading the spoils into cars, by which it is transported to suitable dumping grounds, but the difficulties of determining the best arrangement of excavators and car tracks for excavating this part of the cut, the uncertainty that any definite plan can be advantageously carried through without change, and the intricate nature of the problem itself, have failed to be convincing when critically studied. These estimates of time have often been little better than the offhand opinions of experts who are familiar with that class of work, but who have not formulated a definite project for its accomplishment. It is an intricate problem at best, not solved by multiplying the capacity of one excavator on similar work by the number of excavators that it may be assumed can be advantageously employed.

The number of steam shovels that can be profitably worked simultaneously on this section is limited, the difficulties of laying tracks so that the excavators may work continuously are great, the necessity of steep grades or long approaches to reach the various elevations complicates the problem of transportation, the material in the higher parts of the cut is such that it can not be excavated in the wet season to advantage, the lack of dumping grounds in the vicinity, and the frequent stoppage of work due to torrential rains all tend to render calculations as to daily or yearly output uncertain. To some extent this is true of a cut of less depth than that necessary for a sea-level canal, but in a far less degree.

The problem of excavating 50,000,000 cubic yards of material, all above water, is far less difficult to solve than is the problem of excavating 110,000,000 cubic yards, much of it below water. Whatever lessens the magnitude of the work reduces to a greater or less extent the uncertainties of its accomplishment within a specified time. All the high-level projects have been designed with a special view to reducing the magnitude of this cut. If it can be lessened 50 per cent, the task is not only rendered less difficult, but the time and uncertainty of its accomplishment are proportionately reduced.

The excavation of the 15,000,000 cubic yards below water will require different treatment from that above that level, but how it can best be done has never been definitely determined.

The chief engineer of the Nouvelle Panama Canal Company formulated a well-defined plan for excavating this cut for a canal 112 feet wide on the bottom and with a summit level of about 97 feet. The amount of material to be removed, however, from the deep part of the cut was only about 13,500,000 cubic yards as compared with 32,000,000 cubic yards in the sea-level project.

The estimated time for making it of these reduced dimensions was nine years.

No one will question the engineering ability of Mr. Louis Choron, the chief engineer of the Nouvelle Panama Canal Company, who made this estimate of time, nor will any reasonable person question the fact that there were many reasons why the Nouvelle Panama Canal Company should desire to make this estimate as small as possible and none for making it large. Mr. Choron's assumed average output per steam excavator per day of ten hours for each working day of the year was 444 cubic yards—only a few cubic yards less than the average on the Chicago Drainage Canal.

On the Isthmus, the work being done most of the time under Chief Engineer Wallace, with nine modern American steam shovels, the total output for the nine shovels between February 1, 1905, and July 1, 1905, was 386,185 cubic yards. The number of excavator days made during this time was 714, and the daily average yardage was 541 cubic yards.

On the Chicago Drainage Canal, the largest work of its kind ever undertaken in this country, a work which all will admit was done rapidly, economically, and judiciously, located in a favorable climate, with ideal material to be excavated, abundant labor of all kinds available, located at the very threshold of a base of operation, its dumping grounds alongside within a very few feet, so that the problem of transportation was the simplest and every other condition favorable, yet the average output per steam shovel on that work was 575 cubic yards per shovel per day of ten hours. On the Isthmus the conditions are reversed. Under the circumstances is it safe to assume that the output per shovel on the Isthmus can be reckoned at nearly double what was accomplished on the Chicago Drainage Canal?

I think the time that has been estimated for the excavation of the sea-level canal is very much underestimated.

Senator MORGAN. Before you reach another proposition, I want to ask you one question that strikes my mind: I suppose from the map that is spread out before us, the bottom parallelogram there represents the prism of the canal?

General HAINS. The blue one is the prism accepted for making the estimate for the sea-level project.

Senator MORGAN. Yes.

General HAINS. The red one is the cross-section taken for estimating the lock-canal project.

Senator MORGAN. Yes; the bottom one represents the sea-level and the one above it represents the lock canal?

General HAINS. Yes, sir.

Senator MORGAN. I notice that there is quite a difference in what I will call the steepness of the cuts between the two.

General HAINS. Yes, Senator; I will refer to that matter.

Senator MORGAN. You will refer to that?

General HAINS. Yes, sir.

Senator MORGAN. Very good. I will not ask you any question about it, then.

General HAINS. The cost of maintaining that canal, it seems to me, can only be properly estimated by considering the interest on the extra amount of money invested in the work; and if this be considered, it is readily seen that the cost of maintenance will be far less for the lock canal than for the sea-level canal. That is another reason why I prefer the lock canal.

There are to-day, according to the report of the majority, 322 ships having a beam of from 65 to 85 feet.

Senator MORGAN. In the world?

General HAINS. Yes, sir. There are 183 having a beam of over 70 feet, and there are 82 that have a beam of over 75 feet. There are 82 ships afloat now that have a beam of 75 feet or upward.

Senator DRYDEN. Those are ships throughout the whole world?

General HAINS. Yes, sir; throughout the whole world.

Senator TALIAFERRO. Did you get the draft of those ships that you are speaking of at the same time?

General HAINS. Not all of them; no, sir. We have got the draft of the largest ships. I can give you the draft of about ten of the largest ships in the world, presently, if you would like to have it.

Senator TALIAFERRO. I suppose that your purpose there in giving the sizes of the beams of those ships that you have just spoken of is to show the difficulty that they would have in passing each other in the narrow channel of the sea-level canal?

General HAINS. What I want to show is that the canal is too narrow; that the sea-level canal as proposed by the majority of the Consulting Board is a canal that is too narrow, and therefore it is not the kind of a canal that they seem to refer to as being what was required by Congress.

Senator SIMMONS. The draft is sufficient, General, and that is the reason you have not taken into calculation the draft of these vessels, is it not?

General HAINS. Well, I have made a little sketch——

Senator SIMMONS. I mean the depth of the sea-level canal is sufficient, and therefore you have not taken into this calculation the draft of the ships?

Senator TALIAFERRO. But, Senator, the width of the canal is very different on the top from what it is on the bottom, and it only requires the deepest draft vessels to observe the bottom lines of the canal in navigating the canal. For instance, a vessel drawing 25 feet of water would go very much nearer the shore of the canal than a vessel drawing 30 feet of water.

General HAINS. Oh, yes.

Senator TALIAFERRO. And it is for that reason that I think the draft should go with the beams of those ships in order to make your illustration perfect.

General HAINS. I will come to that presently, in referring to the depth of the canal. The depth of the lock canal is 5 feet greater than that of the sea level.

Senator KITTREDGE. Where?

General HAINS. Throughout its whole length.

Senator KITTREDGE. Is it 5 feet deeper through the Culebra cut?

General HAINS. Yes, sir.

Senator MORGAN. Do you mean as a matter of measurement?

General HAINS. I mean the canal is dug 5 feet deeper. The sea-level canal is 40 feet deep. The lock canal is no where less than 45 feet deep.

Senator TALIAFERRO. Including the locks?

General HAINS. No, sir; between the locks on one side and the locks on the other. The entrances in both cases are the same depths.

Senator TALIAFERRO. What is the width of the sea-level canal on the top?

General HAINS. At what point? It all depends on the place.

Senator TALIAFERRO. At that part of the canal where it is 150 feet at the bottom?

General HAINS. The width at the top there would be—it would add over 200 feet. It depends on the slopes. They have made the slopes one on two in some cases, and one on three, I believe, in others. If the slopes are one on two—is that what it is, Major?

Major HARBOD. One on two, except through the harbors, where it is one on three.

General HAINS. Yes; one on two. That adds four times forty, which is 160 feet, and that would make the canal 310 feet wide on the surface.

Senator MORGAN. We have a map of it there, and can get the measurements exactly from that?

General HAINS. Yes, sir.

Senator MORGAN. The measurements of both the sea-level canal and the lock canal are shown upon that diagram, I suppose?

General HAINS. Yes, sir.

Senator MORGAN. So that we can get it exactly from that?

General HAINS. You can not get the width on the surface from that, Senator, and that is what the question was. Those are the bottom widths shown on that map.

Senator MORGAN. Oh!

General HAINS. The widths on the surface would be considerably greater where there is a slope.

Senator TALIAFERRO. Taking the average vessels that you think would pass through either of these canals, if constructed, would there be any difficulty in vessels of average size passing each other in the sea-level canal?

General HAINS. No, sir; not of the average size; but the law under which this canal is to be built does not call for the average vessel.

Senator TALIAFERRO. No; but I merely asked for your view as to the practical operation of the canal.

General HAINS. Oh, yes, sir; that is correct. It will thus be seen that it is impossible for eighty-two ships of the world to pass each other safely in the narrow part of the canal; that is, in the 150-foot part.

Senator MORGAN. Of the sea-level canal?

General HAINS. Yes, sir; of the sea-level canal. If two large ships were coming in opposite directions one would have to wait at some place near the end of the canal until the other passed. Would a canal subject to such restrictions fairly meet the views of the board as expressed in the following paragraph:

"The vastness of the interests to be served by the canal, many of which interests now wait for their development on the construction of the waterway, demands that the canal shall, when opened for traffic, be of the type which will most perfectly fulfill the purposes which the waterway is intended to accomplish."

Senator DRYDEN. As you go along, General, I want to understand you, and I think I misunderstood you a moment ago. You made a statement to this effect: That if two large vessels had to pass each other one of them would have to wait at the entrance of the canal before the other could pass, as I understood you?

General HAINS. It would have to wait at some other place—at a wide place.

Senator DRYDEN. You did not mean that it would have to wait outside, in the bay?

General HAINS. Oh, no, sir. I did not mean out there. There are places at each end of the canal where they could wait, or they might wait in the Culebra cut.

Senator DRYDEN. That is all that I wanted to ask.

General HAINS. It is to be noted that the narrow part of the canal—that is, of the sea-level canal—is the part where the current will be the swiftest. That is this part right down here [indicating on map].

Senator TALIAFERRO. Is that on the Pacific side?

General HAINS. No, sir; that is on the Atlantic side.

Senator TALIAFERRO. Have you not more current to deal with on the Pacific side than you have on the Atlantic side?

General HAINS. In the sea-level canal?

Senator TALIAFERRO. Yes.

General HAINS. No, sir.

Senator TALIAFERRO. Is there not a rise of tide of 8 or 10 feet more on the Pacific side than on the Atlantic side?

General HAINS. Yes, sir.

Senator TALIAFERRO. Is not that what makes your currents?

General HAINS. No, sir.

Senator TALIAFERRO. What makes the currents?

General HAINS. The discharge of the Chagres River into the canal.

Senator TALIAFERRO. I did not understand that the Chagres River was discharged into the canal.

General HAINS. Under the sea-level project?

Senator TALIAFERRO. Yes.

General HAINS. Yes, sir; it is discharged into the sea-level canal. There is a dam to be built at Gamboa to regulate that discharge; but that water has got to be discharged, and under the plans of the sea-level canal it has got to be discharged into the canal.

Senator TALIAFERRO. It flows in very gently from this dam. It does not go in with a rush—I mean, under that plan?

General HAINS. Not so very gently, Senator. It has got to come down within a short distance here; from there [indicating on map] it comes down into the canal, and the fall——

Senator SIMMONS. What is the descent in that distance?

General HAINS. When the lake is at its maximum it will be about 170 feet.

Senator SIMMONS. What is the distance down?

General HAINS. As I remember it, I think it will be something less than a mile, or about a mile. One hundred and seventy feet fall in a mile is a pretty good fall.

Senator TALIAFERRO. Does not the recommendation of the Board of Consulting Engineers provide that that Chagres water shall be divided, and shall empty into the canal in each direction?

General HAINS. I do not understand that any arrangements are made to make it flow in each direction; but I do suppose that perhaps a part of it will go toward the Pacific.

Senator MORGAN. That depends on the slope of the bottom?

General HAINS. No, sir; it will depend on the slope of the surface.

Senator MORGAN. Of the surface of the canal?

General HAINS. Yes, sir; of the surface of the water at the time.

Senator MORGAN. At the time?

General HAINS. Yes, sir. There is no exit for any large amount of water on the Pacific side provided. There is a spillway there, but it is not contemplated to discharge very much water in that direction.

Senator KITTREDGE. Do you understand, General, that nothing is done to break the fall of the water from the Gamboa dam into the canal?

General HAINS. No, sir; I do not understand that.

Senator KITTREDGE. What is your understanding about it?

General HAINS. I understand that they are to put a sort of an arrangement of steps to break the velocity.

Senator KITTREDGE. Would that have that effect?

General HAINS. It will to some extent; yes, sir.

Senator KITTREDGE. Do you understand that the water coming from the Gamboa dam is to be introduced directly into the prism of the canal?

General HAINS. I do not understand what you mean by "directly." If you mean that it is to be just tumbled into the canal, without any means for correcting the velocity of the flow, it would destroy the canal, and of course that is not intended.

Senator KITTREDGE. What is planned, as you understand it?

General HAINS. It is intended to have some arrangement for reducing the velocity.

Senator MORGAN. Successive terraces of stone?

General HAINS. Yes, sir.

Senator MORGAN. In steps leading from the dam down into the canal?

General HAINS. And finally a weir for it to pass over.

Senator KITTREDGE. Is it not first discharged into a basin, and then passed out over a weir into the canal?

General HAINS. That has never been worked out, sir, that I know of.

Senator KITTREDGE. Is not that the plan contemplated by the majority?

General HAINS. I do not know that it is.

Senator KITTREDGE. Is not that a feasible proposition from an engineering standpoint?

General HAINS. It is a thing that perhaps will want to be done—something of that kind.

Senator KITTREDGE. It is entirely feasible, is it not?

General HAINS. Oh, yes, sir.

Senator MORGAN. You could not put your weir nearer to Gamboa than about Gigante, could you?

General HAINS. The water from the lake will come down in a trench, you may say, that is to be excavated, and there are to be terraces arranged to break its force.

Senator MORGAN. Yes.

General HAINS. That is what I understand the advisory board to intend; and then there will be a weir along down close to the line of the canal, over which it will pour in a comparatively thin sheet.

Senator KITTREDGE. Creating what strength of current?

General HAINS. Nobody knows.

• Senator KITTREDGE. How swift a current is proper to be introduced into the prism of the canal and not interfere with shipping?

General HAINS. That is a matter of opinion. In the Suez Canal they have nearly 2 miles per hour, I believe, at times.

Senator KITTREDGE. Does that interfere with shipping?

General HAINS. Not there, to any great extent.

Senator KITTREDGE. Would it in this canal?

General HAINS. In that particular part I do not think it would; but down in the narrow part I think it would.

Senator KITTREDGE. Why do you say that water introduced into the prism of the canal in the manner you now suggest would flow toward the Atlantic rather than the Pacific?

General HAINS. You have a lock over on the Pacific side, and you have to use that lock.

Senator KITTREDGE. How much of the time?

General HAINS. Practically all of the time. I am coming to that after a while, to show that I do not believe that that lock can be kept open half the time, as is claimed. It is claimed that it can be kept open half the time, and I do not think it can be done.

Senator MORGAN. You mean the sea-gate?

General HAINS. Yes, sir; I mean on the Panama end.

Senator MORGAN. The sea-level canal at all times must be prepared to receive the normal flow of the Chagres River and to take care of the flood flow, whatever that may be, when it may occur, if I understand the situation. The Chagres River at its normal flow will be at all times entering into the sea-level canal?

General HAINS. Yes, sir.

Senator MORGAN. And at flood tide it will be taken care of by regulating works?

General HAINS. Yes, sir.

Senator MORGAN. That is what I wanted to know.

General HAINS. Yes, sir; that is right.

Senator KITTREDGE. Before leaving the question of width of the canal, how does the width of the Panama Canal as proposed by the majority of the board of consulting engineers compare with the width of the Suez Canal?

General HAINS. Oh, it is wider. The Suez Canal is a little over 100 feet wide; I think it is 112 feet wide now.

Senator KITTREDGE. At the surface?

General HAINS. I do not think that is so much of a point, Senator. It is the width of the bottom that controls.

Senator KITTREDGE. It does for ships of deepest draft.

General HAINS. I am speaking of this canal for ships of the deepest draft. That is the object of making this canal so deep. If you are only going to accommodate ships of the ordinary draft, there is no necessity for spending so many millions of dollars down there at all. We can save a great many millions in that event.

Senator KITTREDGE. Do you remember the depth of the canal at Suez?

General HAINS. Yes, sir.

Senator KITTREDGE. What is it?

General HAINS. About 29½ feet; and they are deepening it now to about 32.

Senator KITTREDGE. Are they having serious trouble with traffic in the meeting of boats?

General HAINS. The largest vessels do not go through there.

Senator KITTREDGE. How many do not go through?

General HAINS. I can not tell you how many, but there are quite a number of vessels that can not go through there on account of their draft. I do not know whether vessels of deeper draft go through there now, but until quite recently no vessel drawing more than 27 feet was allowed to go through that canal.

Senator MORGAN. And no sailing ship ever goes through it?

General HAINS. That I do not know; but 27 feet was the maximum draft of any vessel they allowed to go through there at all. Now, we are going to have vessels drawing 38 feet.

Senator KITTREDGE. What ship do you refer to?

General HAINS. I refer to two ships—the *Mauritania* and the *Luisitania*.

Senator KITTREDGE. What is the length of those ships?

General HAINS. Eight hundred feet, I think it is—yes, sir; 800 feet.

Senator ANKENY. Are those the new Cunarders, General?

General HAINS. Yes, sir. I have this sketch that I would like to show you, showing how easily they can pass each other [exhibiting picture]. There is a sketch showing how they pass each other.

Senator KITTREDGE. The statement was made here the other day, in connection with the draft of those ships, that they were to draw 36 feet.

General HAINS. Thirty-six feet draft? I have a letter here from the agent—

The CHAIRMAN. General, right there, what is the width of this canal that you show here with these two ships in it; is it the sea-level canal or the lock canal that you have the ships in now?

General HAINS. That drawing shows them passing each other in the sea-level canal.

The CHAIRMAN. It shows them in the sea-level canal?

General HAINS. Yes, sir.

Senator DRYDEN. And are they passing as far apart from each other as it is possible for them to do in the sea-level canal?

General HAINS. That is drawn so that they are as close together as 5 feet. You can jump from one to the other; and I do not believe that two big ships of that kind can move at all within 5 feet of each other safely.

Senator DRYDEN. That was not quite my question, General. I think you did not quite understand it. I asked you if they were drawn so as to pass as far apart from each other as possible.

General HAINS. Yes, sir; they touch the ground on each side.

Senator SIMMONS. General, I notice that on the line here at the bottom you have them a little up the slant.

General HAINS. Yes, sir. The canal at the bottom is only 150 feet wide. These vessels are 88 feet wide each, so that if you doubled that, if they drew the full length of the canal, they could not pass at all.

Senator SIMMONS. That would bring them both within those two black lines?

General HAINS. Yes, sir.

Senator SIMMONS. There would not be room for them to pass at all?

General HAINS. This being the slope on which the canal is built they would just about touch the ground there when they are 5 feet apart.

Senator SIMMONS. This would be about 38 feet at that point [indicating]?

General HAINS. No; that would be about 37 feet. This would be 38 down here.

I want to say one thing more about this. Thirty-eight feet is the draft that has been given by the agent of the company in a letter. Thirty-eight feet in salt water means over 39 feet in fresh water, and the sea-level canal is going to have fresh water in it, even in that part of it, a good deal of the time, so that 38 feet does not tell the whole story.

Senator DRYDEN. Would so small a margin as practically 1 foot in the depth be safe for a big vessel?

General HAINS. I should say it was very unsafe.

Senator KITTREDGE. General, do you remember whether the report of the majority of the Board of Consulting Engineers contemplates the construction of passing places?

General HAINS. I remember that the Consulting Board makes no provision whatever for passing places.

Senator KITTREDGE. Is that a difficult proposition from an engineering standpoint?

General HAINS. Is it a difficult one?

Senator KITTREDGE. Yes.

General HAINS. No, sir; not at all difficult.

Senator KITTREDGE. Does it involve much extra expense to construct passing places?

General HAINS. Yes, sir; it involves considerable expense. I think I have something covering that right here in these notes.

Senator MORGAN. Suppose we let the General go on and make his statement right through.

The CHAIRMAN. I think that would be much better, and we would get along faster.

Senator MORGAN. We are breaking in on it and getting it confused.

The CHAIRMAN. General, if you will go right along from where you left off, and finish your statement, we will be glad to hear you.

General HAINS. Yes, sir; I think that would be the better way, and then you can come back.

It is to be noted that the narrow part of the canal referred to is the part where the current will be the swiftest. Under the plans of the Board, the waters of the Chagres River, as well as its tributaries, are taken into the canal, and may often produce a velocity of nearly 4 feet a second. Moreover, the part of the canal where this takes place is the part that has the greatest amount of curvature. That is that part down there [indicating]. This, together with the swift current, will render it sufficiently difficult for a single one of these large ships to be safely managed, even though she have the entire canal to herself. The canal, if subject to such restrictions, would inevitably be deemed inadequate, and its widening demanded.

It is further to be noted that this narrow part of the canal is in cutting, which consists largely of material easily abraded by the current, the result of which would cause a flattening of the slopes and shoaling on the bottom.

In the Suez Canal there are numerous passing places between Port Said and Ismailia, a distance of 47 miles, which is just about the length of this canal. There are 14 passing places in that distance.

The tendency of any stream to establish a tortuous course as a part of its regimen is a well-established hydraulic proposition. This tendency is much increased if it flows between banks of erosive materials, and if it receives sediment-bearing tributaries. It is submitted that this part of the canal must, therefore, be considered as partaking of the characteristics of a sedimentary river, under which it will establish, in time, its own regimen. It is not predicted that it will form the large sinuosities of a sedimentary river flowing through an alluvial plain, but that it will establish sufficient indirections of course and currents to render it unnavigable, as a canal 150 feet wide, for ships of the dimensions for which the law directs that provision shall be made.

A tributary discharging a few thousand second-feet in flood into a channel of about 8,000 square feet cross section will present an obstacle which ships can not pass without being deflected from their courses and thrust against the opposite bank. This is an immediate difficulty, but in time this influent tributary, working during low stages and in floods, will deposit a cone of sediment at its mouth and will erode the opposite bank. This erosion of one bank will be followed by an erosion of the other bank at a point lower down and the deposition of the eroded material in the bed of the canal. This is the law of flowing water carrying sedimentary material; and in this way the alignment of the canal will be impaired and indirection of course and of currents established which will ultimately prove obstructive to navigation.

Senator KITTREDGE. May I interrupt you right there? What is the character of the material right opposite the Gamboa dam?

General HAINS. Oh, it is hard material up there. I am not speaking about that part of the canal, Senator. I am speaking of the lower part of the canal, down between the Mindi River and Bohio, or even up farther than that.

Senator MORGAN. Ten or 12 miles?

General HAINS. Yes, sir—oh, yes, sir; there is more than that. It is this part along here I am speaking of [indicating]. There is about 20 miles of it which is only 150 feet wide—19½ miles, to be accurate. I believe that is what it is.

Senator KITTREDGE. How much current will there be in the sea-level canal from Gamboa to the Atlantic Ocean?

General HAINS. The current down in the lower part is supposed to reach 2.6 miles per hour, or about 4 feet per second.

Senator KITTREDGE. Why do you say "supposed?"

General HAINS. It is calculated to do it.

Senator KITTREDGE. Where is that calculation made?

General HAINS. In the office of the Commission. It was made by the Advisory Board itself.

Senator KITTREDGE. Is that a sufficient current to accomplish the result you indicate?

General HAINS. Yes, sir; I think so.

Senator MORGAN. Such calculations are entirely reliable in engineering?

General HAINS. There is only one question about it, Senator, in my mind; I do not know but what those currents may be a little swifter. The Consulting Board admit that there may be a velocity of about 2.6 feet per second, but I am not sure but what there will be more.

Senator MORGAN. You have formulæ by which you make the computations that are uniformly used everywhere?

General HAINS. Oh, yes, sir; yes, sir.

Another reason why I do not like the sea-level canal is because it requires many more dams, and one dam which is much larger than any required by the other plan. I do not mean to say that any of these dams are going to be difficult engineering problems; but they are there.

Senator MORGAN. Are these dams that you speak of for the purpose of producing divergence of water to keep it from flowing into the canal?

General HAINS. Yes, sir; there are about thirty of them. There are about thirty dams between here [indicating] and Gamboa that have to be built before you can build your sea-level canal.

Senator DRYDEN. Do you say that there is one dam larger than the proposed dam at Gatun?

General HAINS. Yes, sir; the Gamboa dam is larger. That holds a head of 170 feet, while this one down here only holds a head of 85 feet; but there are over 30 dams to be built along that route.

Senator DRYDEN. What is the length of that large dam there for the sea-level canal?

General HAINS. This one [indicating]?

Senator DRYDEN. Yes.

General HAINS. The dam is in three pieces. The big section is something like 2,000 feet, as I remember.

Senator DRYDEN. Three thousand or 2,000?

General HAINS. Two thousand. I think it is about that. It is on the drawings. I do not remember those figures.

Senator MORGAN. General (if the committee will excuse me for asking a question that is momentarily applicable and very important, I believe), taking into consideration the cost of the thirty dams you speak of as regulating the flow of the affluents of the Chagres River into the canal, is it not probable that the cost of a sea-level canal between Gamboa and, we will say, Mindi or Gatun would be less if it were dug right down through the marginal peaks of the Chagres River on the right bank, and the dump thrown into the river?

General HAINS. I have never investigated that question, Senator; I could not say.

Senator MORGAN. You would certainly get rid of a great many of the affluents by such a course, by digging your canal so as to hug the mountain here right along down and throwing the dump into the valley of the river. I do not mean the river bed, but I mean the lowlands.

General HAINS. I can not answer your question, Senator. I have never given sufficient study to that particular project. What I wanted to state now was one of the reasons why I do not favor a sea-level project. As I stated, there are about 30 dams along the line of that canal that are to be built.

Senator MORGAN. Between Gamboa and the bay?

General HAINS. Between Mindi, say, down near the end, and Gamboa. The Chagres River sometimes discharges in the neighborhood of 100,000 cubic feet a second at Gamboa.

Senator MORGAN. What rise would that be above the ordinary surface?

General HAINS. About 40 feet. Before you can build your canal you will have to divert the waters of the Chagres. Now, if you do not have any of those big freshets while you are building this diversion, you will have no trouble. But this diversion channel is not contemplated, or has not been contemplated by anybody that I know of, to be anything like as big as the Chagres River itself. The consequence is, if you take the discharge of the Chagres River into this diversion channel, you are going to have a great, big river going down to the sea alongside of your canal while your canal is being built; and if it breaks in on you, my opinion is that the damage will be immense. Just exactly what it will be I do not know; no one can predict what it will be. It will depend on how big a freshet it is.

After the canal is finished these diversions are to be dispensed with, and all these streams, both the Chagres and the other tributary streams along there, are to be taken into the canal—that is, most of them. There are four or five down at the lower end that are permanently diverted.

Senator MORGAN. Along with that flood of 40 feet at Gamboa in the Chagres?

General HAINS. Yes, sir.

Senator MORGAN. They are all to be taken into the channel of the canal?

General HAINS. The river now is known to rise at Gamboa about 40 feet.

Senator MORGAN. Yes.

General HAINS. And if you get a rise of anything like 40 feet in your diversion channel, you can easily see that when you cross the river you will have to have a tolerably good-sized dam to keep the water out.

Senator MORGAN. Let me ask you if it is a fact now that a rise of 46 feet is recorded at Bohio?

General HAINS. Forty-six feet?

Senator MORGAN. Yes.

General HAINS. No, sir; I think about 39 is about the highest that they ever had any record of, Senator, at Bohio.

Senator DRYDEN. Then this danger that you speak of, of the water of the Chagres breaking out of this conduit proposed to be constructed, would be present during the whole time of the construction of the canal—somewhere from twelve to twenty years?

General HAINS. Yes, sir.

Senator MORGAN. Just there there is a point of interest in my mind which I would like to have solved. The conduit you speak of means a channel running up toward the sea through the coastal plain?

General HAINS. No, sir; not through the coastal plain. I will explain it here from this map, Senator. This is a large map [producing new map]. Here is the Chagres River. Here is a part of the old French diversion. There it goes, along there, until it runs into the river. Every little while they make use of the river for the purpose of

reducing the cost of this diversion channel—so they use that, and that is the plan in the Consulting Board's project.

Senator MORGAN. General, where is Gamboa on that plan, please?

General HAINS. It is up here. It is not on this map, Senator; it is up here farther.

What I wanted to show you by this is about these dams. Here is a diversion channel, you see, coming along here, and here is the canal [indicating]. This canal crosses the river there [indicating]. You will have to have a dam on this side to keep this diversion channel from discharging into the canal while you are constructing it. You will have to have another dam here, because this is the diversion channel that is part of the old river used for diversion, and you will have to have another dam here to keep that water from going into the canal, or into the partially constructed canal; and the same way here and here and here [indicating]. Here is this diversion channel, passing along from the old bed of the river, going up this way, into the Frijoles. Then it goes down the Frijoles into there [indicating]. But you must put a dam down here, and you must put a dam there [indicating] to keep that water from going down into your canal.

The Consulting Board estimated three and a half millions of dollars for these diversion channels, for the dams, and all the necessary adjuncts of taking these waters afterwards into the canal itself. Our Commission went over those estimates and came to the conclusion that the estimate was about six and a half millions too little.

Senator MORGAN. They estimated it at three millions?

General HAINS. Three and a half, and I think we made it about ten—somewhere along there. I do not remember the exact figure, but it is about ten millions.

Senator KITTREDGE. Before you start in on that subject I would like to ask you one or two questions on the subject of the water supply. What is the variation in height of the water at the Gatun dam at high water and at low water?

General HAINS. I think they count on about 3 feet variation.

Senator KITTREDGE. Is it not about 5 feet?

General HAINS. No, sir; I do not think there will be as much as 5; and it is not necessary, really, to have any material fluctuation in that level. If you build a dam at Gamboa or Alhajuela so as to control the water up there, control the flow into that big lake, I do not think there will be as much as 3 feet.

Senator KITTREDGE. A dam at Gamboa or Alhajuela is not contemplated under the minority or lock plan, is it?

General HAINS. It is not contemplated; no.

Senator KITTREDGE. Then why do you speak of that feature?

General HAINS. A dam there, at one of those places, is provisionally contemplated if ever the traffic through the canal should become very great.

Senator KITTREDGE. So that the supply of the water should be diminished to such an extent that it should become necessary to use the additional water; is that it?

General HAINS. No; it is so as to hold back a sufficient amount of water to supply the needs of the dry season.

Senator KITTREDGE. According to your statement, then, there is a variation of 3 feet?

General HAINS. Yes, sir.

Senator KITTREDGE. So that at some times of the year—in the dry season, I suppose—the height of the water at the Gatun dam will be 82 feet?

General HAINS. Yes, sir; I suppose it would get down to 82 feet sometimes. It might; I do not know. I have not worked that out, but I think they contemplate a variation of about 3 feet.

Senator KITTREDGE. And if the engineers have testified that it was a variation of 5 feet, would you be surprised?

General HAINS. Yes, sir; I think I would.

Senator KITTREDGE. Now, assume that it is 3 feet in the dry season, that would reduce the depth of your water through the entire distance between the locks, would it?

General HAINS. Yes, sir.

Senator KITTREDGE. So that at some seasons of the year, then, the maximum depth of water in the canal proposed by the minority would not exceed 42 feet, would it?

General HAINS. It might not exceed 42 feet for a very short time, Senator; there are but three months of the dry season, and if there is a falling of the lake and it only falls 3 feet, the 3 feet is only reached toward the last part of the dry season.

Senator KITTREDGE. But it would be reached at some time during the year?

General HAINS. Oh, it might be reached; yes.

Senator KITTREDGE. And when that condition was reached it would reduce the depth of your water to 42 feet, would it not?

General HAINS. To 42 feet; yes, sir.

Senator KITTREDGE. And the capacity of the canal is limited by the minimum depth?

General HAINS. Yes, sir.

Senator KITTREDGE. Then, instead of 45 feet of water it would be 42, would it not?

General HAINS. The way I should put that would be that you might have 42 feet for a few days; you would only have less than 43 feet for about a month and a half; and you would only have less than 44 feet for about, say, two months and a half; and for all the year except about three months you would have 45 feet.

Senator KITTREDGE. Your statement a few moments ago to us that the lock plan which you favored would permit a draft of water of 45 feet was subject to the exceptions you now state?

General HAINS. Yes, sir.

Senator KITTREDGE. That is what I had in mind.

Senator MORGAN. Just one more question before you proceed; it will only take a moment to answer it. In the construction of a sea-level canal, commencing at the Bay of Limon and running up, say, as far as Obispo or Gamboa, would it be necessary to divert the channel of the Chagres so as to enable the dredges to operate that would come in from the sea?

General HAINS. Yes, sir.

Senator MORGAN. It would be necessary to divert the channel of the river?

General HAINS. Yes, sir; all the way.

Senator MORGAN. And you think that the dredging could not be

done from the Bay of Limon, up to, say, Gamboa or Obispo, without that diversion?

General HAINS. No, sir; I do not think it could be done. I think it would be unsafe to try it.

Senator MORGAN. Unsafe?

General HAINS. Yes, sir.

Senator MORGAN. You mean by that, I suppose, that in the flood waters all of the work would be swept out by the flood unless you took care of it by diverting it?

General HAINS. Yes, sir.

Another reason why I prefer the lock canal is on account of the less depth of cut in the Culebra, and because the deeper the cut the greater is the liability to injury to the slopes. Landslides (I do not mean large landslides) have been frequent there. Small slides have occurred along the portion where the cut has already been made; and you will find some of these referred to in Colonel Black's reports. I have seen a good sized spring coming right out of the side of that cut.

I do not wish to be understood as saying that that becomes a matter of serious danger; but these landslides, or these slides of these pieces, which may occur and are apt to occur, will cause constant expense for reconstructing them in some way or other. The way the Frenchmen did, when they had slides in those places, was more like that [indicating]; they would build those up again; and you will find in Colonel Black's reports that there were numerous cases where those slips (I call them slides, you might call them slips) would have to be rebuilt, one or two at a time. You have to put it back; you have to build up a dry stone wall of masonry; and it has been done, and it is there now.

Senator KITTREDGE. Have the small lines passing through the blue and the red or pink on that map any significance?

General HAINS. Merely to indicate the general slope. That line is drawn so as to show that this is a general slope of 1 on 1, 1 base to 1 vertical; and this is put in to illustrate the manner in which this slope is cut. It is not cut as a straight line, right down that way, but with these steps in it.

Senator MORGAN. Those benches are about 25 feet on the front?

General HAINS. Different engineers have different ideas about it. On the sections adopted by the Consulting Board they are about 12½ feet wide.

Senator MORGAN. On the flat, on top?

General HAINS. Yes, sir.

Senator MORGAN. What is the frontage?

General HAINS. And 30 feet high. This is about 30 feet high, and that is about 12½ feet across there [indicating].

Senator MORGAN. Is 12½ feet width enough to carry a railroad track?

General HAINS. I do not think it would be advisable to put railroad tracks along there, on all of those places, or, in fact, on many of them.

I do not suppose, Senator, that it is necessary for me to refer to Colonel Black's reports. I have his reports here, but if you do not care to hear about them I will pass that matter over.

Senator MORGAN. I think we had better get all the information we can while we are at it.

Senator KITTREDGE. State the substance of them, at least.

General HAINS. I can hardly state the substance, Senator. I will just take two brief paragraphs from his reports. Here is a report that

he made—a general report by Major Black. I will just look at the date of it.

Senator KITTREDGE. Is that made to us, General?

General HAINS. No; it is made to the Isthmian Canal Commission. It was about the time that the canal was taken over by the United States. He had been down there a year keeping account of the work that was being done by the French company.

Senator MORGAN. He was “guardian ad hock;” he was guardian over the establishment until we took it over?

General HAINS. Here is what he says about slips in the cut:

“The adopted project calls for terraced side slopes above the water level, with levels 5 meters wide, spaced vertically 10 meters apart, and slopes between these levels with an inclination of 5 vertical to 2 horizontal, excepting in clay at the top, where the inclination is 2 vertical to 3 horizontal. These slopes have proved too steep in many instances, and falls of rock and clay have been frequent. When these falls took place from the slopes of finished sections efforts were made to rebuild the slopes and restore the broken levels with dry rubble masonry or with riprap. It is rare where this work has remained in place. The force in my charge was too small to keep an accurate account of all of this kind of work done, which must be classed as useless. For two points, however, it is possible to give a fairly accurate estimate.

“In May a slide took place on the east side of the cut, at kilometer 54+975”——

That is a position that the map can show, as to where it was. [Reading:]

“Carrying away parts of levels 67 and 75. Work was begun at once to restore these slopes and levels by building a dry rubble wall. The wall fell once shortly after it was started, and in part once after completion. It was finally repaired in July, and stood fairly well until November, when it was again carried away and has not yet been restored.

“Another fall took place in May on the east side, at kilometer 55+110, carrying away portions of levels 67 and 75. An effort was also made here to restore level 75. This work was also carried away in October.

“During the months of May, June, July, and August a force was employed on this work at a cost of \$822.70 Colombian silver. Other work of the same kind was done, but it has been impossible to obtain data on which to base an estimate of its cost.”

In another part of that same report he says:

“None of the black rock of the heart of the Culebra Hill has been found at a depth below +45 on the east side of the cut, or below +50 on the west side. Blue clay underlies it. This fact should be considered carefully in making projects for the slopes of the finished work. The effect of the lack of homogeneity in the material forming the slopes is to make it impracticable to hold a continuous steep slope.

“Slips occur where the different formations abut, and also where a previous layer is found beneath the surface to which water can find its way. When the final project is made the question of slope of the bank must be left for local determination. Each section should have a treatment best suited to the material of which it is composed. No money should be expended in attempting to obtain regularity of slopes.

When a stable slope is obtained in a finished section it should be planted with vegetation. The upper surface of all level(s) for a distance of at least 200 meters from the superior crest should be kept carefully drained. During operations working levels, when needed, should be kept at least 10 meters wide."

I only quote this to show that it is a mistake to suppose that there are no slips.

The CHAIRMAN. General, is that an official document?

General HAINS. Yes, sir.

(General Hains was requested by the committee to obtain a dozen copies of the report for the use of the committee, and stated that he would do so.)

The CHAIRMAN. Now, General, kindly proceed with your statement.

General HAINS. Another reason for preferring the lock canal is that it affords a better regulation of the Chagres during freshets. The regulation of the Chagres River during freshets is a very important question. The lack of preparation on the part of the French in the first case—that is, under the De Lesseps Company—was, I think, largely due to the fact that they did not provide for a good regulation of the freshets. This large lake, which is over 103 or 104 miles, I think, in area, is so large that all these freshets that come in from the little streams or from the Chagres River itself come in there and cause no trouble at all, because these freshet waters are dumped right into still water, and there is no trouble about it, except that it rises a little. But it takes a great deal of water, you know, to make a foot of rise on a lake that is 104 miles in area; and then they have the spillway to regulate the flow, anyway.

I have already spoken of the currents in the sea-level canal; and that is another reason why I prefer the other, the lock canal. There are no currents in the lock canal. The lock canal is the kind of canal that is ordinarily understood when we use the word "canal." A canal does not generally have a swift current in it, and there is no current in that canal; so that that is another reason.

Senator KITTREDGE. Do you call a current moving at the rate of 2½ miles an hour a swift current?

General HAINS. Yes, sir; I do. For a big ship, I do.

Senator ANKENY. Do we understand, General, that this drift of the Chagres waters will make what we call at sea a 2½-mile drift? You had some computation of your own about the Chagres waters that I do not understand; but is it what a seaman would call a 2½-mile current?

General HAINS. A 2½-mile current; yes, sir.

Senator ANKENY. You have to meet that to stand where you are?

General HAINS. That is what you have to do. If you are sailing with the current you have to keep steerageway in that current, and that necessitates your going—well, if you wanted to make 4 miles an hour against that current you would be making only, really, 1½.

Senator ANKENY. In other words, you have to meet the 2½-mile drift?

General HAINS. That is what you have to do.

Senator ANKENY. Yes; thank you.

General HAINS. There is another reason which, perhaps, many persons will regard as not a very strong one, but I think it is a reason of some account—that a sea-level canal after it is finished is not finished.

That is, I mean that that sea-level canal (referring to majority plan) is not finished, and it never will be finished; and there is going to be a constant demand for widening and deepening or something or other, and I think it is going to be a drain on the Treasury which, I think, is unnecessary.

Another reason is that a lock canal is a fresh-water lake. It has a large fresh-water lake in it; and while this may not be of great value, still it is a good thing to have this large area in here in which vessels can anchor and clean their bottoms. If the amount of commerce that is being provided for ever goes through that canal those lakes will be very useful for a vessel to stop and clean in.

Senator ANKENY. Do you not think, General, that there is a good deal of nonsense about fresh water relieving a ship of her barnacles?

General HAINS. Fresh water does not relieve a ship of barnacles, Senator.

Senator ANKENY. Can you not clean your ship in any other place just as well, then?

General HAINS. You could, in fresh water. What I am referring to in speaking of cleaning is the destruction of the marine growth, like grass, that forms on the bottom of a ship.

Senator ANKENY. You did not have the barnacle altogether in mind, then?

General HAINS. No, sir; I did not have the barnacle in mind.

Senator ANKENY. But you are familiar with what is so often said about that?

General HAINS. Yes. I do not think you will clean off the barnacles down there. I think there is only one safe way, one proper way, to clean off barnacles, and that is to dock your ship.

Senator ANKENY. Yes; that is right.

General HAINS. But the grass and that stuff that grows on a vessel whenever it is in the tropics for any length of time would drop off itself in fresh water.

Another reason is that the lock canal can be deepened more readily and widened at less cost than the sea-level canal. It would be a very slight expense to raise the canal walls and the height of the lock gates and the spillway in order to get, say, 1 or 2 or 3 feet additional, whereas to get additional depth in the sea-level canal would be a very expensive operation.

I think there is considerable uncertainty in the estimates, from this cause: The uncertain elements are much greater in the case of a sea-level canal. There is an uncertainty about those slopes in the Culebra cut, and there is considerable uncertainty as to the damage you will get in constructing that sea-level canal. Those uncertainties do not apply to the other canal.

The sea-level canal also has a large amount of rock excavation below tide level in it.

There is another point, and that is in regard to the claim that has been made that the lock gates in the sea-level canal can be kept open half the time. I think that is decidedly an error. I think we will find in the Panama Canal just the same thing that occurred in the Kiel Canal. They thought they were going to keep the gates open there most of the time, and they find that they can not do it. They find that they have to keep those gates closed. I have not a drawing of the gates, but I suppose you understand very well that you will have two

sets of gates, one working in one direction and the other working in the opposite direction.

You have a rise and fall of the tide on the Pacific end, and a constant level in your canal, or very nearly constant, and this rise of the tide at times ranges from about 5 or 6 feet above mean sea level to about 10 or 11 feet, and it falls from about 5 to 6 feet below that plane, making a total oscillation of something like—I think the minimum there is about 9 or 10, and the maximum about 21.

These tides occur twice a day. You will have two low tides and two high tides. The consequence is that as soon as the tide begins to rise, say, your gates would be open, your canal is at mean sea level, and you have your gates open, and that is the level on the Pacific side. You have your gates all opened. Now, as soon as the tide begins to rise you must close them. You must close the upper ones in order to lock down. There will be great difficulty in closing those gates as soon as the current begins to run through there. That current has been found at the end of the Kiel Canal to be very troublesome, so that now they keep those gates closed all the time. The conditions are not very much different there, either, because they do not have as much rise and fall of the tides as we have at Panama; but they do have strong tides that cause considerable rises.

Senator KITTREDGE. Accompanied by wind?

General HAINS. Yes, sir.

I think the picture of a vessel damaging the canal by going through the locks, plunging down through a gate, and all that sort of thing, is very much overdrawn. There is no difficulty, to my mind, in providing a temporary structure that could be sunk down in the foundation just ahead of the upper lock-gates, so that in case anything happened below you could raise it just like you raise one of the Stoney gates. The Stoney gates are built certainly over 30 feet wide, I know, and I do not know how much wider; but a caisson could be sunk into the foundation there which could be raised without any great trouble. That would cut off that water before it had created any great damage. I do not mean to say that it would not damage anything at all, but it would not be nearly so great as one might suppose.

As to the difference of danger in time of war, I do not think there is much difference. I think a neutral canal would be the best protection that you could give it. There is no canal down there that is going to be of any use to the United States unless we command the Caribbean Sea; and you may fortify it all you please and it will not do any good. You will merely create a military outpost down there which is hard to reach, but which it will be necessary to reach and keep up communication with, and it would hamper the Navy to such an extent that I think the efficiency of the Navy would be very much reduced.

Senator KITTREDGE. May I interrupt you right there? Do I understand you, General, to say that you think that in the event of war this Government would be better off without the canal than with it?

General HAINS. No, sir; I did not say that.

Senator KITTREDGE. Just what did you mean by your last statement?

General HAINS. I spoke of a neutral canal. I say that I do not think there is any great difference as to the danger of the canal being destroyed, we will say, temporarily or permanently, during war, but that I would

rather depend on the neutrality of the canal than on anything else to defend it.

Senator MORGAN. But, General, you do not think a neutral canal there is possible when we are engaged in belligerency with a great power? We, as a neutral, can not permit the vessels of any great power to pass through there when we are at war with it, if they are going out west to attack our Pacific coast, or coming in to attack the Atlantic coast with a great fleet, can we? We could not endure that kind of neutrality.

General HAINS. Well, Senator, there is this about it: Any navy that can force its way to the canal is going to render the canal absolutely useless to us.

Senator MORGAN. Why, of course; that is unquestionable. We would have no commerce.

General HAINS. If you will allow me, I would rather pass that matter over just now.

Senator MORGAN. Yes.

General HAINS. Now, I want to speak with reference to the slopes in the Culebra cut.

The slopes in the Culebra cut of the sea-level project above the 50-foot berm—that is this [indicating]—are taken as 3 vertical to 2 base in what is classed as rock, and 1 vertical to 2 base in earth or clay. Those for the lock project are the same, but in the lock project provision is made for an extra berm for every 150 feet rise. That is, they have an extra berm here for every rise of 150 feet. There is not much of a distance where you have over 150 feet, but you can see that this wide berm gives a good chance for any slips that may occur.

The CHAIRMAN. What is the width there, General, at the top?

General HAINS. Fifty feet. The slopes, therefore, in the lock plan are flatter and safer and approach more nearly those heretofore used for estimating purposes. The technical committee of the French company adopted slopes of about 1 on 1. The Isthmian Canal Commission of 1899 adopted slopes of 1 on 1. Mr. Wallace, former chief engineer of the Panama Canal, in his estimates adopted slopes above the berm of 1 on 1. In Mr. Wallace's report of February 1, 1905, made to the Isthmian Canal Commission (I think you have it here; I saw somebody have it yesterday), he gives an estimate of the cost of making the excavation from Bohio to Miraflores for a sea-level canal 150 feet wide and 35 feet deep, with berms 50 feet wide, and with slopes of 1 on 1 above the berm and 1 on 2 below it. You understand what it is—that is, 1 on 2 in that lower end [indicating on map].

Senator ANKENY. What degree is that?

General HAINS. One on 2 would be about 30 degrees to the horizontal, I think it is. This is 1 on 2 [indicating].

Senator ANKENY. Forty-five degrees?

General HAINS. No, sir; that is not 45. This other is 45. One on 1 is 45. That is flatter.

The quantity of excavation between Bohio and Miraflores estimated by Mr. Wallace for a sea-level canal is given as 250,000,000 cubic yards. The amount of excavation is for a canal 35 feet deep and 150 feet wide at the bottom.

The estimate of the Consulting Board for this portion of the sea-level canal is 176,005,291 cubic yards, but the canal is 40 feet deep throughout the entire distance between Bohio and Miraflores, and

more than one-half of it is 200 feet wide. In other words, the estimated excavation for this part alone of the larger canal is about 74,000,000 cubic yards less than the smaller one. Now, had the estimate of the Consulting Board been based on the same slopes that were used by Mr. Wallace in his estimates for this portion of the canal, the total quantity of excavation would not have been less than about 285,000,000 cubic yards.

I do not claim that Mr. Wallace's estimates are more nearly correct than those of the majority of the Consulting Board, but they are certainly safer estimates. The errors, if any, are more likely to be on the safe side, and the liability to errors is great.

The engineering committee of the Isthmian Canal Commission, in its report of February 14, 1905, adopted Mr. Wallace's estimates for that portion of the canal, as will be seen by the resolution unanimously adopted by that committee and referred to on page 14 of their report.

Has any new data been brought to light that justifies the use of these steeper slopes in estimating the quantities of excavation? I certainly know of none, and I am quite sure that the character of the material has not changed within the past year.

I speak of this for the purpose of showing that the sea-level advocates have adopted much steeper slopes than have ever been used heretofore for estimating purposes.

Now, these slopes may stand. I do not say that they will not; but I think it is very unsafe to adopt such steep slopes when there is a good, strong possibility that they will not stand.

Senator KITTREDGE. In other words, you would eliminate all possible danger?

General HAINS. Well, I do not think I would eliminate it altogether by taking slopes of 1 on 1; but I think I would come nearer to eliminating it than by taking anything steeper.

Senator KITTREDGE. In other words, you would advise us to take the absolutely sure course?

General HAINS. Well, I do not know that 1 on 1 is absolutely sure, but it is certainly safer than any steeper slope, and 1 on 1 is the slope that has been adopted heretofore in all the estimates—about 1 on 1. The French had very nearly the same thing; we had the same thing—that is, the Isthmian Canal Commission had the same slopes, and Mr. Wallace used the same slopes, but the Consulting Board, after their examination, came to the conclusion that you could put in a great deal steeper slopes.

Senator KITTREDGE. You advise taking the safe course?

General HAINS. I advise taking the safer course.

Senator KITTREDGE. And that is true of every matter, I suppose, connected with the canal proposition?

General HAINS. Well, I do not know that that would be true. There might be some things where the total advantages on one side would outweigh a course that would be perfectly safe, and you might be willing to take some risks on something; and possibly you would take risks on this. I would prefer not to, in the estimates. I am only speaking of the estimates. The tendency of this is to reduce the estimate of the sea-level project to a greater extent, proportionately, than the estimates for the lock-canal project.

Senator KITTREDGE. In other words, "in case of doubt take the safe course." Is that it?

General HAINS. No; I do not say that exactly, either. In respect of the expenditure of so much money, I think the estimates for the sea-level project will certainly be something like \$150,000,000—from \$125,000,000 to \$150,000,000, say—more than for the other canal. That is my opinion; and I do not see that there is sufficient reason for spending that additional money, even though the sea-level canal had some advantages.

As another reason, I think that the lock canal is really a shorter canal than a sea-level canal. By cutting off through here [indicating] you can reduce the length of that canal 1 mile. That does not amount to much, but still it is something.

I think there is another objection. I think that in a great project like this, involving a large expenditure of money, extended over a prolonged period, the people may become tired of appropriating money and refuse to complete it. I do not think that is an imaginary proposition.

Senator MORGAN. That is where the whole work is going to break down unless we succeed in getting something that they can understand, and that they feel that they can face. It will all "go to pot" unless we do it.

General HAINS. I have a note here on the subject of the opinions of different engineers on this subject.

The first canal that was attempted to be built on the Isthmus was a sea-level canal, substantially the same sea-level canal that is now proposed by the majority of the Board of Consulting Engineers. It occupies the same location in the territory. It provides for a high dam at Gamboa and the holding back of the waters of the Chagres River above that dam, and differs from that of the Consulting Board only in some of its details. The plan of the Consulting Board, of course, enlarges that of the first French company, and extensive changes are made at the two harbors; but essentially it is the old, discredited De Lesseps project of the sea-level canal revived, with enlargements and modifications.

After the failure of the first company a body of engineers known as the Commission d'Etudes, composed of eleven engineers eminent in their profession in Europe, was organized by the Liquidator in 1889. After a careful study of the technical questions involved in the problem of the canal, it rendered its report in 1889. This commission reported in favor of the abandonment of the sea-level canal and the adoption of a project for the completion of a canal with locks. Subsequently another commission, known as the Comité Technique, was organized, composed of fourteen engineers, many of them engineers of the highest standing in the civilized world. They made a report in 1898, recommending a lock canal.

Another commission, known as the Comité Statutaire, composed of five members, and all except one of them being new men, reported in favor of a lock canal. Later the Isthmian Canal Commission rejected the sea-level plan and adopted the lock plan. There were six engineers in that Commission, so that there were no less than thirty-four engineers opposed to the sea-level plan. It is believed that the weight of evidence against the sea-level project and in favor of the lock project can not be ignored in making a decision.

Here follow the names of the engineers referred to. I will not read them, because, in fact, I do not believe I could pronounce them all correctly, any way.

Senator MORGAN. They will go into the record, though.

General HAINS. But there they are.

Senator MORGAN. Lamberton was one of them, was he not?

General HAINS. No, sir.

(By direction of the committee, the following names, referred to above by General Hains, are printed as a part of the record):

M. Guillemain, inspector-general and director of the National School of Bridges and Routes of Communication.

M. Chaper, engineer in the corps of mining engineers.

M. Cousin, engineer in the corps of bridges and routes, of Belgium, and professor in the University at Louvain.

M. V. Daynard, formerly naval engineer, chief engineer of the Trans-Atlantic Steamship Company.

M. Descubes Du Chatenet, engineer in the corps of mining engineers.

M. Germain, hydrographic engineer of the navy.

M. Holtz, chief engineer, and professor in the National School of Bridges and Routes of Communication.

M. Lagout, engineer in the corps of bridges and routes of communication.

M. Nivoit, chief engineer in the corps of mining engineers, and professor in the National School of Bridges and Routes of Communication.

M. Renoust Des Orgeries, inspector-general in the corps of bridges and routes of communication, retired.

M. Van Zuylen, colonel of engineers, and formerly chief engineer of the army of Holland in the East Indies.

M. Robaglia, inspector-general of the corps of bridges and routes of communication, retired.

M. Bouvier, inspector-general of the corps of bridges and routes of communication, retired.

Gen. H. L. Abbot, colonel of the Corps of United States Engineers, retired.

M. Castel, inspector-general of the corps of mines, retired.

M. Fargue, inspector-general of the corps of bridges and routes of communication, retired.

M. Ftely, chief engineer of the aqueduct commission of New York City, and past president of the Society of Civil Engineers.

M. Fulscher, consulting engineer of the ministry of public works of Prussia, and formerly chief engineer of the Kiel Canal.

M. Hersent, civil engineer, constructing the new docks at Antwerp.

M. Hunter, chief engineer of the Manchester Ship Canal.

M. Koch, consulting engineer of public works, director of the Technical Academy at Darmstadt. Formerly technical member of the imperial commission of the Kiel Canal.

M. Jules Martin, inspector-general of the corps of bridges and routes of communication, retired.

M. Skalkowski, formerly director of the department of mines in the ministry of agriculture and State property of Russia.

M. Sosa, chief engineer of Colombia (graduate of the Troy Polytechnic Institute, New York).

M. Paul Etienne, chief engineer of the corps of bridges and routes of communication.

M. Joseph Barba, formerly engineer in the French navy and chief engineer at the iron works at Creusot.

M. Marcel Bertrand, member of the Institute of France, chief engineer in the corps of mines, and professor of geology at the National Higher School of Mines.

M. Philippe Zurcher, chief engineer of the corps of bridges and routes of communication.

Mr. George S. Morison.

Lieut. Col. Oswald H. Ernst, Corps of Engineers, U. S. Army.

Mr. Lewis M. Haupt, civil engineer.

Mr. Alfred Noble, civil engineer.

Col. Peter C. Hains, Corps of Engineers, U. S. Army.

Mr. William H. Burr, civil engineer.

General HAINS. In this connection I quote the following extract from a letter from Chief Engineer Stevens. He states in the letter that "of the engineers who are now on the Isthmus in the employ of the Commission, of all ranks, of all degrees of experience and knowledge, I have yet to find a single man who is in favor of a sea-level canal. Most of them are very outspoken against such a proposition; and while it may be said that they are not world-wide men in technical knowledge and experience, I claim that an intimate knowledge of the conditions obtained by a residence of months and years on the ground is of far more value than any theories or any conclusions which may be drawn from existing works in other parts of the world which bear not the slightest resemblance to the proposition at Panama."

Senator KITTREDGE. Will you give the date of that letter?

General HAINS. December 19.

Senator KITTREDGE. To whom was it addressed?

General HAINS. To the chairman of the Commission.

Senator KITTREDGE. Will you please have that entire letter sent up?

General HAINS. I suppose the chairman will. The chairman of the Commission will send it to you, I suppose.

Senator KITTREDGE. Will you see that it is done?

General HAINS. I shall speak to him about it; yes.

Senator KITTREDGE. Returning to the question I asked you before you began to make your statement and relating to the matter that you have just mentioned, I call your attention to an article by Rear-Admiral Chester, found in the National Geographic Magazine for October, 1905, vol. 16, No. 10, and read, as follows:

"While on the Isthmus during the latter part of 1887 I ventured to ask Mr. Charles de Lesseps, who was then the company's manager, if he really expected, as was then widely published, that the canal would be completed the following year. He replied that, while he would not like to have it known, he did not mind telling me that in order to complete it at that time, as well as to procure a revenue for continuing digging down to sea level, the company might be forced to the lock system of construction. This would surely be accomplished in the end"—that is, the sea-level proposition.

General HAINS. Oh, yes.

Senator KITTREDGE. I move that we adjourn until half past 2.

Senator MORGAN. Just one question before we go.

The CHAIRMAN. All right, Senator.

Senator MORGAN. General, if the country between Gamboa and Pedro Miguel was as open and as easy of being cut through by digging or by dredging as the country between Bohio and Gamboa, would you prefer a lock canal across between Gamboa and Pedro Miguel to a sea-level canal through that same area?

General HAINS (after a pause). I do not know that I could answer your question offhand; but I am rather inclined to think, Senator, that I would prefer a sea-level canal under those circumstances.

Senator MORGAN. That is all I wanted to ask.

(The committee thereupon took a recess until 2.30 o'clock p. m.)

AFTER RECESS.

STATEMENT OF BRIG. GEN. PETER C. HAINS—Continued.

The CHAIRMAN. General, are you through with your statement? Had you finished when we took the recess?

General HAINS. I do not think there is anything else that I care to speak about.

The CHAIRMAN. Senator Morgan, will you take the matter up with the General?

Senator MORGAN. Yes. General, you were on the Board of Consulting Engineers, were you?

General HAINS. No, sir.

Senator MORGAN. You were on the Commission?

General HAINS. I am on the Commission.

Senator MORGAN. The only questions that were submitted to the Commission with respect to the type of the canal were a lock canal over the entire width of the Isthmus or a sea level canal under the entire width of the Isthmus, were they not?

General HAINS. Well, there were several different types of lock canals.

Senator MORGAN. But I speak of the question submitted by the President.

General HAINS. He directed us to submit such plans as had been proposed to or might be proposed by us to the Consulting Board.

Senator MORGAN. Well, the only two plans you conferred about were a lock canal and a sea-level canal?

General HAINS. Those are the only things that you could have. It is a question between a canal with locks or a sea-level canal.

Senator MORGAN. A canal with locks meant a canal with locks clear across the Isthmus?

General HAINS. Yes, sir.

Senator MORGAN. Not partially across?

General HAINS. No, sir.

Senator MORGAN. You did not confer together or consult together about the question of a canal that would be partly a sea-level canal and partly a lock canal?

General HAINS. Yes, sir; we did that. You know the project of the Isthmian Canal Commission itself is partly a sea-level canal.

Senator MORGAN. How far?

General HAINS. From Bohio to the Atlantic it is sea-level, and from Miraflores to the Pacific it is sea-level.

Senator MORGAN. That is the old Isthmian Canal proposition. That is what you mean?

General HAINS. Yes, sir.

Senator MORGAN. The proposition of the Walker Exploration Commission?

General HAINS. Yes, sir. That was the French project, too.

Senator MORGAN. With a dam and locks at Bohio?

General HAINS. Yes, sir.

Senator MORGAN. And at Pedro Miguel and Miraflores on the other side?

General HAINS. Yes, sir.

Senator MORGAN. Then it would be dredged out to a sea-level canal from that out?

General HAINS. To sea level from that out.

Senator MORGAN. The canal as recommended by the Walker Commission of exploration was a sea-level canal to Bohio?

General HAINS. Yes, sir.

Senator MORGAN. And a lake canal from that up across the divide?

General HAINS. Yes, sir.

Senator MORGAN. With an 85-foot elevation?

General HAINS. Yes, sir.

Senator MORGAN. And then a sea-level canal from Miraflores out into the Pacific—out into the bay?

General HAINS. Yes, sir.

Senator MORGAN. If you had absolute certainty of putting in a dam at Bohio would you not be disposed to adhere to that plan?

General HAINS. I would be willing to build that plan, but I think with a good lock site at Gatun I would prefer to build the Gatun lake rather than the Bohio lake.

Senator MORGAN. Yes; with a good lock site?

General HAINS. Yes, sir.

Senator MORGAN. And how about a dam site?

General HAINS. And a good dam site.

Senator MORGAN. I suppose, of course, you have examined carefully and exhaustively the proposed site for a dam at Gatun and the site for a spillway cut through the hill there?

General HAINS. Yes, sir.

Senator MORGAN. And the site for the locks on the right bank of the Chagres?

General HAINS. Yes, sir.

Senator MORGAN. Have you no misgivings as to the canal that is proposed to be built there, as to its permanency?

General HAINS. No, sir; I think the dam will be permanent, and the site for the locks is a good one.

Senator MORGAN. Does it furnish an extensive length of earth, with sufficient foundation for three twin locks in flight, to accommodate a ship 900 feet long?

General HAINS. Ample.

Senator MORGAN. You have made measurements, and you have satisfied yourself?

General HAINS. I have examined the drawings that we have, and when that question was raised a short time ago—a few days ago, in fact—Mr. Stevens was asked to report on it, and he made a report. I

believe the substance of it was read yesterday by General Ernst, saying that there was room enough to put a flight of three locks in tandem, and have each lock over 1,100 feet long.

Senator MORGAN. To be permanent and satisfactory and safe, within engineering comprehension and calculation, those locks should be underlaid by a rock foundation?

General HAINS. Yes, sir; that is what they are.

The CHAIRMAN. Senator Morgan, there is a paper that was sent into the room this morning by Mr. Shonts, and I think I will hand it to General Hains, and he might read it and have it go into the record. It seems to pertain to the Gatun dam [handing paper to General Hains].

General HAINS. I have never seen this cablegram.

The CHAIRMAN. One is a cablegram from Mr. Shonts to Mr. Stevens, the chief engineer, and the other is the reply from Mr. Stevens to Mr. Shonts.

General HAINS (reading):

ISTHMIAN CANAL COMMISSION,
Washington, March 26, 1906.

SIR: I have the honor to transmit, for the information of your committee, the following cable correspondence:

"STEVENS: Wallace condemned Gatun site because rock foundation unobtainable and indurated clay with gravel boulders and sand below not sure protection against seepage. Flatly contradicted Stearns and declared permanency earthwork dams on Isthmus not demonstrated by experience because of different conditions. Said three locks in flights dangerous, because required continuous construction concrete approximately mile long, and unless material uniform settlement be unequal, with disastrous results."

"SHONTS."

"MARCH 23, 1906."

"SHONTS: In regard to Wallace's testimony, character of foundation Gatun locks absolutely prohibits the slightest chance of any settlement. This can not be too strongly emphasized."

"STEVENS."

March 24, 1906.

Very respectfully,

T. P. SHONTS,
Chairman.

Hon. JOSEPH H. MILLARD,

*Chairman Senate Committee on Interoceanic Canals,
United States Senate, Washington, D. C.*

Senator MORGAN. Well, as far as that goes, it is first a statement as to what Mr. Wallace's testimony was.

General HAINS. Yes.

Senator MORGAN. In which, I think, he does not represent Mr. Wallace correctly, as the record will show. The balance of it is not the statement of any fact, but the statement of an opinion. Do you know any fact to show that a rock foundation—and I am not talking about an indurated clay foundation—that a rock foundation can be had

for those locks at the site of the Gatun dam, to be practically a mile long? Have you seen any borings that would disclose that there was a rock foundation there practically a mile long?

General HAINS. No, sir; I have not seen the borings. I understand that Mr. Stevens has made a number of borings, but we have not had a report of them.

Senator MORGAN. You do not know what they are?

General HAINS. No, sir; I do not.

Senator MORGAN. Running a line a mile long, in which to put three locks of 1,100 feet you would not know how deep you would have to go beneath the level of those locks to strike rock?

General HAINS. I do not know of my own personal knowledge, no, Senator; the borings heretofore made did not cover the whole of the site. They changed the site of the locks slightly. The line of boring, however, which were made a little at an angle to it showed good foundation.

Senator MORGAN. As far as the borings extended?

General HAINS. Yes, sir; and they went as far as it was necessary if the locks had been put in that location.

Senator MORGAN. And at that angle?

General HAINS. At that angle; but they changed it and swung it around.

Senator MORGAN. They swung it around so as to make it more directly parallel to the general course of the canal?

General HAINS. I think that was it. I think so; yes.

Senator MORGAN. The first proposition would have brought the ships into the locks at an angle to the canal?

General HAINS. Yes; it runs off that way, and they put it in so that it will run off in that way [indicating on map]. Yes; that is correct.

Senator MORGAN. So far as this committee is informed, that is the opinion of Mr. Stevens without its being supported by actual borings which he has described to you in any way. He has not described any borings to you?

General HAINS. Not many borings. There are borings that are referred to in the report of Mr. Maltby, which he sent up.

Senator KITTREDGE. When was that done? When was the report to which you referred?

General HAINS. I think they were made last November, for the Consulting Board.

Senator MORGAN. Well, we have to leave that proposition, as I take it, as the matter stands before the committee now, for the want of proper information.

I will now turn across the site of the dam, on the blueprint here. In passing to the westward from the site of the locks in the direction of the hill through which the waste way is to be constructed you pass a gulch that appears to have been washed out of the indurated clay, in the shape of an inverted cone, that is put down on this blueprint here as being—

General HAINS. That is that one over here [indicating on blueprint]. This is the west one [indicating].

Senator MORGAN. Is that the west one?

General HAINS. Yes; that is the first one.

Senator MORGAN. Then I will change my question. You pass a gulch that is bored down to a depth of 210 feet below sea level, which

gulch is how wide at sea level? I do not know how to compute it on this map.

General HAINS. Pretty nearly 2,000 feet. A little less than 2,000 feet across.

Senator MORGAN. That gulch is pretty nearly 2,000 feet across?

General HAINS. At the top; yes.

Senator MORGAN. That has also been washed out of the indurated clay?

General HAINS. Well, perhaps.

Senator MORGAN. It is there?

General HAINS. It is there.

Senator MORGAN. Have you any better way to account for it than that it has been washed out?

General HAINS. I have no better way to account for it, but I do not know whether that was the way it was formed or not.

Senator MORGAN. We do not any of us know, but we have to take the probabilities and compare them and arrive at what we conceive to be, at least, a fair conclusion. All of that gulch is filled up with permeable material, is it not?

General HAINS. No, sir; I think that material is mostly impermeable.

Senator MORGAN. Down in that gulch?

General HAINS. Yes, sir.

Senator MORGAN. Where is the permeable part of it, on top—at the upper part?

General HAINS. Down at the bottom. The most permeable part is down at the bottom.

Senator MORGAN. The report of the borings there is that at the depth of 50 feet below sea level, I believe it is——

General HAINS. About that.

Senator MORGAN (continuing). The wells that were driven down for the purpose of ascertaining whether the water was in here and in here [indicating on blueprint] brought up water at a uniform level, or about a uniform level, in each of these gulches. The engineers who testified here, I believe all of them, come to the conclusion that the water that was thus forced up through those pipes belonged to a common body, and that what went up through the pipes in this deep gulch was the same body of water that went up through the pipes in the shallower gulch, and that therefore there was some substructure or substratum that was permeable, and there was communication on each side of this island. Do you concur in that?

General HAINS. That there was communication?

Senator MORGAN. Yes; between the waters.

General HAINS. No, sir; I do not.

Senator MORGAN. You do not?

General HAINS. No, sir.

Senator MORGAN. They spoke very decidedly about that, particularly Mr. Wallace. There is permeable material, though, lying at the bottom of this broad gulch that I have just described, and also this narrower one which runs down to 258 feet below sea level?

General HAINS. Yes, sir.

Senator MORGAN. The permeable material is in the bottom of these gulches?

General HAINS. Yes, sir.

Senator MORGAN. Do you consider that there is no necessity for stopping off the flow of water in the permeable material or otherwise obviating it or obstructing it in order to get a firm, permanent basis for the dam that reaches across both these gulches?

General HAINS. I do not think there is any necessity for stopping that seepage. At the same time I believe that seepage can be stopped, and at no great expense, either.

Senator MORGAN. How would you proceed to do it?

General HAINS. There are two methods that I have in mind which are practicable, in my opinion. One is to force cement grout down into that permeable material—that is, it is coarse sand, which will fill up the interstices and solidify the whole of it, making it practically rock. I do not regard that as at all an impracticable undertaking.

Senator MORGAN. Let me ask you right there whether you know of any great dam that has ever been filled upon such a foundation?

General HAINS. Such a foundation as that?

Senator MORGAN. Yes; a cement foundation pumped into the bottom of it.

General HAINS. No; I do not recall any where any seepage has been stopped by this process—that is, for any great depths. The Assiut dam, on the Nile, is built entirely on sand, and for a great depth under it—I do not know how many feet—but for a great depth under it there is nothing but sand, all of which is water-bearing, with a pressure of water in the river above the dam considerably above that below it.

Senator MORGAN. Are you speaking of the dam that spans the Nile, or the dam that flanks it?

General HAINS. It spans the Nile at the place called Assiut. I am not speaking of the Assuan dam. The Assuan dam is built on rock.

Senator MORGAN. Yes.

General HAINS. I mean one up near Cairo. This dam has had grout forced under it to so solidify the material to a depth of something like 30 feet, I think.

Senator MORGAN. Thirty feet?

General HAINS. Yes, sir.

Senator HOPKINS. And below that is the sand, through which the water seeps or can seep?

General HAINS. Yes; it is supposed to seep through there, but it has not affected the stability of the dam.

Senator MORGAN. Is that an earth dam or a sand dam, filled up on top of that?

General HAINS. That is a masonry dam.

Senator MORGAN. A masonry dam built on the top of this—

General HAINS. On this sand foundation.

Senator MORGAN. Filled with grouting?

General HAINS. The under part; yes, sir. The underlying sand is filled with this grouting.

Senator MORGAN. Like a rock core underlying it?

General HAINS. Yes, sir.

Senator DRYDEN. How long has that dam stood there?

General HAINS. I do not know when that dam was built, but I think it was built more than ten years ago.

Senator HOPKINS. What is the head of water?

General HAINS. That I can not say.

Senator MORGAN. About 25 feet, is it not?

General HAINS. I would not like to say, Senator. It is a matter that can be determined accurately. I do not carry these figures in my head any more than I can help, because I find that if I try to do it I am very apt to make mistakes.

Senator MORGAN. You have described one process by which you would undertake to intercept the water down there at the base of these two gulches. Is there any other process that you would rely upon?

General HAINS. Yes, sir; there is another process that I think could be applied there. That is, by using steel sheet piling. If you will let that stand over for a few minutes, Senator, I have sent down for a specimen of this sheet piling, from which, when it is sent up here, I can show you how I would put it down, if you do not already understand it.

Senator MORGAN. I do not understand about the sheet piling. I never saw any of it, but I have heard it described a time or two—not described really, but referred to.

Would you feel safe in putting in such a dam as is to be superimposed above these two gulches without any protection against the percolation of water at the foundation among this coarse material?

General HAINS. I should feel perfectly safe without it, yes.

Senator MORGAN. Have you any example of engineering in your mind that would give you a precedent that would contribute to your feeling of satisfaction and safety?

General HAINS. I do not recall just now large dams built on that kind of a foundation, but my understanding is that there are a number of them.

Senator MORGAN. Small dams, but not reaching down to two or three hundred feet, are there?

General HAINS. I say I do not recall any that are anything like these dimensions.

Senator MORGAN. It is the head of water that impinges against the dam, or presses upon the dam, that causes the danger of the washouts, is it not?

General HAINS. Yes, sir; and if it is not intercepted in some way or other there would be a head of water of 85 feet on the up-stream side of the dam, and if there was a streak of permeable material running from, say, what is now the bottom of the Chagres River, down that way and running out [indicating on map], some water would seep through; but I have no idea that the amount of seepage would endanger the dam. It might cause a loss of water, and if it was a case of water supply to a city it would be necessary to cut it off, because it might be of some importance; but in a case like this, where the number of feet are calculated to be so small, I can not see that there would be any danger from it. The mere seepage of the water through this stuff underneath does not, in my opinion, render the dam unsafe at all. If it could go through there with a velocity so as to move the particles along with it, that would be an entirely different thing; but it can not do that.

Senator MORGAN. When we find four or five engineers and they divide about equally, and one expresses the opinion that that is an element of danger, and the other expresses an opinion that it is not an element of danger, what are the laity to do?

General HAINS. Senator, you are in the same fix about the two types of canal.

Senator MORGAN. It looks to me as if we had better get a chuck-luck box and throw high die for a judgment about it. [Laughter.] But they are all opinions. It is your opinion that this dam can be built upon this structure without anything being put down into this soft material, this coarse material.

General HAINS. Yes, sir; that is my opinion.

Senator MORGAN. That is your opinion. If it is the opinion of another engineer, say with equal experience and ability, that it can not be done with safety, would it not be better, General, in that case, to discard both of them and take a plan that does not require any dam?

General HAINS. Why, no; I think the best thing under those circumstances is to accept what they say about its being dangerous and cut it off, which I say you can do by grouting it or by this steel sheet piling.

Senator TALIAFERRO. How much will that increase the cost?

General HAINS. Oh, I should not think it would add a half a million dollars to it.

Senator MORGAN. Well, that is not much in these times, you know, except to the taxpayers. They feel it sometimes, a little bit.

General HAINS. Speaking about this sheet piling, Senator, here is a specimen of it. That can be driven down. There is another piece over it, like that [indicating], and that goes on here, with this part right in there [indicating], and that is used for cofferdam purposes now. It has been used to great depths, and after it is down it is absolutely tight. You can pump water out of that with perfect impunity.

Senator MORGAN. Would that sheet piling be put down in sections like this?

General HAINS. Not in sections like this. This is just a short section. It would be long, you know. It would be long enough to reach down to the bottom of the gulch here.

Senator MORGAN. To be secure, I suppose it would have to reach from the bottom of the gulch up to the—

General HAINS. Clear up to the water surface, if you wish.

Senator MORGAN. Up to sea level?

General HAINS. Yes, sir; or even above it, if you want it to.

Senator MORGAN. It would not be put down as one solid mass of sheet piling, but it would be put down in sections, one resting upon the other?

General HAINS. One after the other.

Senator MORGAN. Driven down upon the top of each other?

General HAINS. Not on top of each other. You start with one up here, where you do not go down very deep. That gives you the bearing for the next one. [Indicating on blueprint.] Then you come with the next one, and that goes down still deeper. Then you come with the next one, and that goes down still deeper, and then the next one, that goes away down here [indicating on blueprint] into this what you call indurated clay, which I think is a misnomer; then this one, and then this one, and so on, until you get across the valley. Then across the whole of this, if there is any seepage through it, it will be stopped, admitting that there is seepage. I do not think there is any except down at the bottom; but by this means you will cut it

off. In the same way you will cut it off on this one [indicating on profile].

Senator MORGAN. If you use that sheet piling, or if you use the cement grouting, we will call it concrete—

General HAINS. Not concrete, Senator.

Senator MORGAN. Well, grouting.

General HAINS. It is just cement and water mixed together.

Senator MORGAN. That is all?

General HAINS. Yes, sir.

Senator MORGAN. If you use either, how are you going to fasten that to the walls of this indurated clay, as you go down, so as to prevent a crack? You fill up across this gulch a broad sheet, in order to cut off the water; how are you going to fasten the bearings or the edges of this, either the sheet piling or the cement, to the wall of this indurated clay, so as to prevent a crack there?

General HAINS. The sheet piling I would drive into this indurated clay, driving it in a short distance. That will answer that question, I believe.

Senator MORGAN. Laterally in the side walls as you go down?

General HAINS. You see this is exaggerated [referring to blueprint profile]. This distance across here is about 3,000 feet, and this distance from here to here is only 200; so that you see that this sugar-loaf line, you may say, does not convey the correct idea.

Senator MORGAN. Yes.

General HAINS. If this vertical scale was the same as the horizontal one, the bottom of that gulch instead of being away down there would be about there [indicating on blueprint profile].

Senator MORGAN. Yes.

General HAINS. You see, this is exaggerated. The scale is exaggerated in the vertical direction. If that were drawn according to the regular scale, it would come down along here [indicating]. That is the way that would be.

Senator MORGAN. But still it would come down in the form of an inverted cone?

General HAINS. Yes, sir.

Senator MORGAN. A sharp inverted cone?

General HAINS. Yes, sir; but instead of looking like a cone, it would be just a slight depression, like that; and that is all it is, in the rock.

Senator HOPKINS. This does not fairly represent it, then [referring to blueprint profile]?

General HAINS. No, sir; that is exaggerated.

Senator MORGAN. That is exaggerated, but the figures are all there.

General HAINS. The figures are all there, but it is exaggerated in order to put in these notes about what was found at different depths. That is a common practice. We always use those in drawings.

Senator MORGAN. This island of indurated material here, too, is exaggerated in the same way?

General HAINS. Yes, sir.

Senator MORGAN. So that, relatively, they are right, but nevertheless, in this direction—that is, toward the bottom of the blueprint—the appearances are calculated to deceive the eye.

General HAINS. That would be right down like that, if it was on the same scale [indicating].

Senator MORGAN. Yes. I want to know, when you have got your steel sheet piling driven in there and fastened in the walls on either side, if there is not still an element of danger in the cracking of that material and the disarrangement of the vast mass of earth that is piled upon it?

General HAINS. No, sir; I do not consider that there will be any danger from it, even though such a thing should occur. That dam is a very big one.

Senator MORGAN. You proceed now with the dam from east to west?

General HAINS. Say northeast to southwest. That is about the direction.

Senator MORGAN. Well, eastwardly and westwardly?

General HAINS. Yes, sir.

Senator MORGAN. You proceed with that dam, building it from the locks across these two gulches, and the next place you come to is that island?

General HAINS. Yes, sir.

Senator MORGAN. That mountain, or——

General HAINS. You mean the hill in between?

Senator MORGAN. Yes, sir.

General HAINS. That is this place here [indicating on the map]?

Senator MORGAN. Yes. You have got to provide for attaching your dam to that hill in some way?

General HAINS. No, sir. It is not necessary to make any provision for that. Your dam is of earth. The dam that is proposed there is of earth, and a slight cut into the hill will give you all the means of connection that will be necessary.

Senator MORGAN. That is attaching it, as I call it.

General HAINS. Yes; well, I thought you meant in some way——

Senator MORGAN. I did not mean riveting it, which would be a pretty hard thing to do. (Laughter.) I am talking about making the connection a solid one.

General HAINS. There is no trouble about that.

Senator MORGAN. The hill there is composed of material that has been there for ages and ages, and of course it has all settled together perfectly compact.

General HAINS. Yes.

Senator MORGAN. Your dam, no matter how carefully you put it in, is not quite as compact as that hill is going to be?

General HAINS. No; not quite.

Senator MORGAN. And if there is any convulsion, or any unusual pressure of water, or any other accident, we will call it—a convulsion or movement that affects this dam—would it not be most likely to invade the point of contact between the dam and the hill? Would not that be the weak point in the structure—the point of contact?

General HAINS. No, sir. If there should be any opening, the earth would fall into that opening and there would be some settlement of the dam. That is all that would occur.

Senator MORGAN. That is exactly what I am expecting, that there would be a settlement of the dam.

General HAINS. That would not do any harm.

Senator MORGAN. If it produced fissures, when you had 85 feet head of water on it, a small crack might produce absolute destruction?

General HAINS. Well, if it produced a large fissure and that fissure remained open and water got running through it, yes. But I do not see how such a thing as that could occur in there.

Senator MORGAN. If you will think a moment, General, of the way the crawfish serve the levees on the Mississippi River you will find it out. A crawfish will bore a hole through one of those levees in the night, and the next morning it is a crevasse.

General HAINS. Yes; but the distance through a levee is a very different thing from the distance through that dam.

Senator MORGAN. That dam would have a very long reach; but I suppose a crack or a fissure might occur in it that would reach, say, half a mile through it, or a mile, even a small one; and would not that endanger the whole structure? You have no rock core there to resist it, nothing to resist the fissure that might be attacked by the water at 85-foot level. Suppose that fissure occurred 10 feet under the water and was half a mile long, from the settling of the dam and the settling of the stuff that you put in there to continue the barricade made by the mountain, would not that be an element of danger in that dam?

General HAINS. I do not think there would be any more element of danger than if you had a core wall in there, because I think your core wall would break, too, if you had a convulsion of nature that would open a space wide enough for the water to run through there. The destructive effect would also break your core wall.

Senator MORGAN. Yes.

General HAINS. So that, under such circumstances as that, I do not see that you would be any better off with a core wall than without it.

Senator MORGAN. That hill through the center of which you cut your spillway is a volcanic hill or elevation?

General HAINS. Well, I do not know.

Senator MORGAN. Does anybody know?

General HAINS. No; I do not think anybody does know.

Senator MORGAN. Have these gentlemen who have projected this dam there ever bored into that hill to examine what was in it?

General HAINS. Where the spillway goes?

Senator MORGAN. Yes.

General HAINS. Oh, yes, sir. I understand that there were borings made in that. We have a record of them here.

Senator MORGAN. Have you any statement anywhere in these papers, or do you know of any fact in regard to it, that will show what kind of rock they found in that hill?

General HAINS. I think so. There are in this hill here six borings right in the hill. Then these others are just beyond it. The spillway goes right through there [indicating on map].

Senator MORGAN. Have you any remembrance, or are you able to state, or has anybody stated, what the material is that they get in these borings—what kind of rock they found?

General HAINS. In these [indicating on map]?

Senator MORGAN. Yes.

General HAINS. There they are, right there. That is it, on the blueprint [indicating].

Senator MORGAN. The character of the material?

General HAINS. That is it, there. Take boring 35 + 14. There it is, right there; from there down to there, to rock [indicating on

profile]. That is that one. That hole there (on map), Senator, is represented vertically there (on profile). It has gone into the rock just that depth.

Senator MORGAN. What kind of rock is it? That is what I want to get at. Is it basalt or volcanic rock?

General HAINS. No, sir. That is what they call the indurated clay. Indurated clay is not the proper name for it. I think Mr. Harrod had better give a definition of that. He has investigated that matter, and he knows what is the scientific explanation of that word, which has been so used, and used with such misunderstanding, this word indurated clay.

Senator MORGAN. I have always misunderstood it. At least, I have never understood it, and therefore have always misunderstood it.

General HAINS. Well, I think if you will just forget the words "indurated clay" and say "rock" you get a better idea of that thing, because it is really rock. I would like Mr. Harrod to just explain that to you. He knows about that.

Senator MORGAN. We want to know what kind of rock it was, and whether it was volcanic or not.

General HAINS. He can tell you better. He has looked into that more than I have.

Senator MORGAN. Along the coastal plain of Panama, in the vicinity along both east and west of the Chagres River, there are these sugar-loaf hills springing up.

General HAINS. Yes, sir.

Senator MORGAN. Not connected by ridges with each other at all.

General HAINS. I know.

Senator MORGAN. Just like potato hills by themselves.

General HAINS. Just like sugar loaves.

Senator MORGAN. I am very much interested to know how they got there, and I suppose that we have got men of science that ought to be able to say. My poor private judgment is that they have all been thrown up exactly in the same way that those mud craters were thrown up in 1882, when the earthquake passed across from Panama to Colon and up the coast toward Bocas del Toro, where these mud volcanoes, miniature volcanoes, were thrown up, and through them came hot water and other evidences of volcanic action.

I have supposed that those mounds were made in the same way, by convulsions of nature, and that they are all volcanic. If they are, then that probably accounts for this queer stuff which underlies that country that we call indurated clay. It may probably show that it is volcanic tufa or ashes that have been indurated there from the pressure of time or air or water or overlying strata, or what not, until it has been compacted together like a rock. It is not sand; it is not granite; it is not, as I understand, any stratified rock.

General HAINS. No, sir; but it is very hard; and it stands well in the weather. I have seen the dock that is used down there on the Isthmus, right close by this place, only a short distance below, where the walls have been cut right down vertically into it, and it stands like the wall of this building.

Senator MORGAN. When you get over into the Culebra cut and into the wells that the French dug down there, that same stuff does not stand at all?

General HAINS. That is not the same stuff.

Senator MORGAN. Does it not look exactly like it?

General HAINS. No, sir.

Senator MORGAN. What is the difference in appearance between the two?

General HAINS. Well, I do not know what the difference would be. I am not a geologist.

Senator MORGAN. I do not suppose any of us are.

General HAINS. And I do not know; but I do know that under the action of the air there is some material which is classed as indurated clay over there in the Culebra cut—

Senator MORGAN. That goes to pieces?

General HAINS (continuing). And after it becomes dry you put it in water and it all melts. There is some of that. This is not that, as is evident from the fact that there is a dock that has been there for I do not know how many years; but I presume for twenty years, and vessels are taken in there and docked. I was looking at it only the last time I was down there.

Senator MORGAN. Right in this indurated clay?

General HAINS. Right in this indurated clay. It makes a splendid vertical wall, and as for a foundation for any kind of engineering structure, I would put the Washington Monument on it.

Senator MORGAN. And nevertheless here are two great gulches that you can not account for, that were washed right out of this indurated clay?

Senator HOPKINS. He did not say that they were washed out of that. Senator MORGAN. I think he did. He said he could not say how else it happened.

Senator KITTREDGE. That was this morning, Senator.

Senator HOPKINS. I know he balked at that this afternoon.

General HAINS. What is that? About how it was formed?

Senator HOPKINS. About its being washed out.

General HAINS. I do not know. I know that it is the opinion of geologists that it has been washed out by the water, and maybe it has.

Senator HOPKINS. If that occurred, it was millions and millions of years ago, was it not, when this was all soft material?

General HAINS. It was a good many years ago; yes. According to geologists it was perhaps millions of years ago.

Senator MORGAN. It has only been twenty-four years since there was an earthquake that passed right along the line of this canal that shook cathedrals down, killed men in Colon, tore houses down, and formed mud volcanoes up as far as Bocas del Toro. That has only been twenty-four years ago.

General HAINS. It did not knock the cathedral down, Senator, because the cathedral is there yet.

Senator MORGAN. It knocked down the tower of it and other churches were torn down.

General HAINS. And it did not injure, and there has not been any injury in something like, well, as nearly as they can tell, it was about some two or three hundred years ago, a building was put up there with an arch much flatter than that [indicating], and wider.

Senator MORGAN. In the first report that you made, General, to the Government of the United States, you said that there were thirty-four earthquakes that had occurred there in Panama. I think it was either thirty-two or thirty-four.

General HAINS. You know there are earthquakes—

Senator MORGAN. And earthquakes.

General HAINS. And there are earthquakes. There are some very little seismic disturbances that might be called earthquakes, and yet do no damage at all.

Senator MORGAN. But this disturbance, General, did actually destroy houses in Panama.

General HAINS. There was an earthquake. I do not remember just exactly the year.

Senator MORGAN. It was twenty-four years ago. That was when it was. And it crossed clear through the Isthmus, and it put the railroad bridges off of their bearings.

General HAINS. Yes.

Senator MORGAN. And inflicted very considerable damage upon the railroad itself, even to the twisting of the rails, and it passed into Colon and threw houses down, and killed men, and then it passed on up the coast to Bocas del Toro, leaving in its trail these pits of volcanic mud, through which steam came up. That is a pretty recent event. I am older than that, even young as I am.

Senator HOPKINS. That line of argument, Senator, would show that you can not build any kind of a canal across the Isthmus there.

Senator MORGAN. Well, it satisfied me a long time ago that you could not do it. I have always said that you could not. [Laughter.] The further we get into it the better I am satisfied that you can not, to make it stay there.

There are still facts and problems that we can not account for, and we can not tell whether they are to be a million years repeating themselves or twenty-four years. We do not know about it. But when a fact like the earthquake of 1881 occurred there, it is the part of good common sense to expect it to come again, is it not?

General HAINS. Yes; and I do not believe such an earthquake as we had then would do this dam any damage whatever, Senator.

Senator MORGAN. You would not like to take the risk of it, would you?

General HAINS. Yes; I would be willing to take the risk of it.

Senator MORGAN. If you were operating on somebody else's money; but suppose you had all of your own money up on it?

General HAINS. If anybody will give me money enough to do it, I will take the risk.

Senator MORGAN. If anybody will give it to you, yes; but if you had to work for it and earn it, and pay taxes on it, and accumulate it, it would be quite a different story. We are trying to take care of the people here—at least, I am. That is all I will ask you about that part of this business.

General, you have been connected with this canal and the project which we are trying now to work out, after two years and a half of effort—you have been connected with it as an engineer since when? When were you first connected with it?

General HAINS. You mean the whole question of the canal across the Isthmus?

Senator MORGAN. When were you first connected with this project officially?

General HAINS. This particular project?

Senator MORGAN. No; making the canal at Panama?

General HAINS. You do not refer to Nicaragua, but—

Senator MORGAN. No; I am just talking about Panama; the time you first went there, if you please?

General HAINS. We were a little over two years—two years and a half on the first Commission and then I have been a little less than a year on the present Commission.

Senator MORGAN. This is the commission of construction, and that was the commission of exploration?

General HAINS. Yes, sir.

Senator MORGAN. You were two years and a half on the first Commission and spent about how much time—about thirty days on Panama during that time?

General HAINS. Well, perhaps something like that.

Senator MORGAN. I think that is it—thirty-one or thirty-two days.

General HAINS. I do not remember the time.

Senator MORGAN. From that time until to-day you have been officially connected with that work?

General HAINS. No, sir.

Senator MORGAN. You have not?

General HAINS. Oh, no, sir.

Senator MORGAN. Where did the break occur?

General HAINS. From January, 1902, or a little later than that, until a year ago. I was not on the first constructing commission.

Senator MORGAN. You were not on the first construction commission. You were on the second?

General HAINS. I am on the present one, but I was not on the first one.

Senator MORGAN. You took your appointment at what date?

General HAINS. The 1st of April, last.

Senator MORGAN. The first of April, 1905?

General HAINS. Yes, sir.

Senator MORGAN. You were familiar with the condition of that canal and of the Canal Zone and the cities of Panama and Colon, and the Bay of Limon and the Bay of Panama. At the time you were making this survey or exploration you knew that whole situation?

General HAINS. I became familiar with it during that time; yes, sir.

Senator MORGAN. It was a part of your business to study it?

General HAINS. To become familiar with it, yes, sir.

Senator MORGAN. You knew it at the time that the canal company turned it over to the United States?

General HAINS. Yes, sir.

Senator MORGAN. General, I shall be glad if you will give to this committee a description of the situation of that enterprise at the time you examined it, in regard to the work that was being done, the hands that were being employed, the government of the canal line, the state of the improvement or dilapidation, as the case may be, in regard to the work that had been done previously by the French company, and the amount of work, depth of the cut through, for instance, Culebra, the amount of digging that had been done there, the length of the canal that had been dug, how much of it had filled up and through whose neglect it filled up, and all that. Just give an account in narrative form of the situation.

I will state to you my purpose. I want to ask you further, after you give your narrative, so as to show what was to be done there in

order to inaugurate and conduct the work we are trying now to carry on. I want to show what task lay before that first commission of construction, and give the country a fair idea of the task that those gentlemen had to perform.

Senator KITTREDGE. Senator, before he answers that question, may I ask one or two questions?

Senator MORGAN. Yes.

Senator KITTREDGE. You were appointed to the present Commission April 1, 1905?

General HAINS. Yes, sir.

Senator KITTREDGE. When did you first go to the Isthmus after that date?

General HAINS. In July.

Senator KITTREDGE. How long did you remain there that time?

General HAINS. About two weeks; a little less, I suppose. About two weeks.

Senator KITTREDGE. When did you return to the Isthmus after you returned to this country?

General HAINS. I have not been down to the Isthmus since then.

Senator KITTREDGE. Was General Ernst with you on the first trip?

General HAINS. No, sir.

Senator KITTREDGE. Was he at the Isthmus at any time since his appointment?

General HAINS. Yes, sir.

Senator KITTREDGE. When?

General HAINS. Since this last appointment he has been down there two or three times—twice.

Senator KITTREDGE. When was that?

General HAINS. He went down in August, 1905; the latter part of July or the first part of August, 1905. Then he was down there again—

Senator KITTREDGE. How long did he remain that time?

General HAINS. I do not know exactly, but I think it was something like two or three weeks.

Senator KITTREDGE. When did he next go down?

General HAINS. In September.

Senator KITTREDGE. With the Consulting Board?

General HAINS. Yes, sir.

Senator KITTREDGE. And returned with them?

General HAINS. Yes, sir.

Senator KITTREDGE. Has he been there since?

General HAINS. I think not.

Senator KITTREDGE. That is all that I wish to ask at this time.

Senator MORGAN. Now, I will ask that my question be read.

(The stenographer read as follows:)

“Senator MORGAN. General, I shall be glad if you will give to this committee a description of the situation of that enterprise at the time you examined it in regard to the work that was being done, the hands that were being employed, the government of the canal line, the state of the improvement or dilapidation, as the case may be, in regard to the work that had been done previously by the French company, and the amount of work, depth of the cut through, for instance, Culebra, the amount of digging that had been done there, the length of the canal that had been dug, how much of it had filled up, and through

whose neglect it filled up, and all that. Just give an account in narrative form of the situation."

General HAINS. You are referring there to the first visit we made in 1899?

Senator MORGAN. Yes.

General HAINS. When we arrived there we found that the French had in their employ from about 700 to 1,000 men. They had a number of excavators at work on the Culebra Cut, and were excavating about 75,000 cubic yards, I think, per month. They had employed dredges on the two ends of the canal, and had done an amount of dredging. They had excavated some of the rock at Bohio, where they proposed to put locks. A certain amount of work had also been done above Bohio and up to San Pablo in rock. Some rock excavation had been done on the Pacific side. They had also excavated a considerable amount of what we call diversion channels—that is, diversions for the Chagres River and its tributaries. Altogether they had excavated something like 77,000,000 cubic yards of material.

A great deal of plant had been accumulated on the Isthmus, a large amount of machinery, and a large number of buildings had been erected. Hospitals had been erected over here at Panama on Ancon Hill. They had also accumulated there a number of dredges and boats. They had I do not know how many dredges, but quite a number; perhaps nearly twenty. They had a large amount of what you might call railroad plant; that is, they had great quantities of railroad track, they had a great number of locomotives, and a large number of cars; and these things were scattered along the line of the canal from one end to the other. They had erected repair shops and that sort of thing.

Senator MORGAN. By "scattered" do you mean scattered in use or scattered in abandonment?

General HAINS. Some scattered in use, and some piled up outdoors, and some in buildings. They had constructed something like 2,300 buildings of all kinds for the storage of this material and for the protection of their employees, but a great deal of this was in a very dilapidated condition. It had not been taken care of for part of the time, but some of it was in fair condition. There was one big storehouse that I remember—I think it was at Gorgona—that was just filled with all kinds of hardware. It was like a great, big hardware store. There was every kind of crosscut saw, every kind of bolt you could imagine, nuts, and so forth, and those things were all in good condition. In some places, however, the weeds had grown up around this material, and it was difficult to find where it was. There were locomotives there that we could hardly find, and cars.

But notwithstanding all that the French Company, the new company, had picked out a certain amount of this plant and were utilizing it on the Culebra Cut. They had regarded that Culebra Cut as, you may say, the controlling feature of the work, and they went to work to find out what was in it. That was what they were working on at the time we were there, and it was the only thing that they were working on.

Senator MORGAN. Finding out what was in that hill?

General HAINS. Yes, sir; trying to find out what was in that hill. At the same time that they were doing all this they were making surveys, as I understand. Now, I can not speak positively about the date when these surveys were all made, but they were making surveys,

and they made a great many surveys. Of course, they had to extend their surveys after they had agreed or about agreed to make a lock canal instead of a sea-level canal.

As to the government down there, I do not know anything about it. The government at that time was the Colombian Government, under the control of the Government of Colombia, and this corporation was a private corporation working in that country. They had had a great deal of trouble from sickness; and it is stated that they were very deficient in the means of accommodating the sick people, and lost a great many hands for that reason. So that when we undertook to make a valuation of this property and the condition of affairs down there, we came to the conclusion that about all that was worth anything to the United States was the amount of excavation that had been done and the surveys that had been made, and, of course, the Panama Railroad. The surveys, as a rule, were very good, very accurate, and very complete, and many of them. They did not make so many borings; but their topographical surveys were very complete.

Does that answer your question, Senator?

Senator MORGAN. I think it does, substantially. You have not said anything about the filling up of the prism of the canal that they had dredged out or dug out.

General HAINS. Oh, well, of course the Chagres River had not been taken care of, and the water came down the Chagres River as usual, and wherever it got a chance to reach a part of the canal where work had been done, of course it brought down sediment and largely filled it up; and there was a great deal of it that had been filled up to a certain extent.

Senator MORGAN. Were those fillings distributed pretty well between Colon and Bohio?

General HAINS. Yes, sir.

Senator MORGAN. All the way down?

General HAINS. There were more of them, down the farther you go.

Senator MORGAN. So that the part of the canal which had been opened was utterly impracticable for any commercial use, was it not?

General HAINS. Oh, yes; it was utterly impracticable.

Senator MORGAN. It was a filled-up ditch, as we call it?

General HAINS. Yes; it was largely filled up.

Senator MORGAN. Obstructed?

General HAINS. It was very much obstructed; but it was obstructed more at points, Senator. There were deep places on a great deal of the constructed portion of the canal.

Senator MORGAN. Yes; of course. Opposite the mouths of streams that came into the Chagres River, of course, there would be banks of silt and obstructions of different kinds?

General HAINS. Yes, sir.

Senator MORGAN. How was it on the other side, between Pedro Miguel and La Boca?

General HAINS. Pretty much the same thing.

Senator MORGAN. It was filled up?

General HAINS. To a certain extent; yes.

Senator MORGAN. While they were working on the Culebra Heights and were doing some work there, you say, with shovels—

General HAINS. They had what they called "excavators."

Senator MORGAN. Excavators?

General HAINS. Yes, sir; they were not steam shovels such as we have now, used on railroad work or on excavating work, but they worked somewhat on a different principle.

Senator MORGAN. They worked by steam, though?

General HAINS. Yes, sir.

Senator MORGAN. And they had the assistance of men with picks and shovels, etc.?

General HAINS. They did not have many of those.

Senator MORGAN. Some of that railroad track that they had built in there, and some of the engines and cars, etc., I suppose, from the accounts you have given me this morning, were covered up by slips or slides?

General HAINS. Not in the Culebra cut; no, sir. What I meant was along the line. They had shipped great quantities of this stuff down there, and they had to put it somewhere, and they had laid off tracks almost anywhere.

Senator MORGAN. At the time you arrived at the Isthmus there were propositions pending for the sale of the canal property to the United States—the transfer of the canal property?

General HAINS. At the time we went down there?

Senator MORGAN. Yes; made through Admiral Walker?

General HAINS. No, sir; not at the time we went down there, Senator. We went down there at the time we were first organized—that is, within a few months after we were organized, and there was no proposition of sale made until a couple of years after that.

Senator MORGAN. You were invited down there by the French canal people to make the surveys?

General HAINS. We were invited, but we would have gone whether we were invited or not.

Senator MORGAN. But you had no right to go without their invitation; it was a foreign country.

General HAINS. Well, we might not have had any right, but I think the right would have been extended to us.

Senator MORGAN. It was not necessary to stand on manners, however, because they wanted you to go?

General HAINS. They wanted us to go; yes.

Senator MORGAN. Yes.

General HAINS. They wanted us to see just the situation there.

Senator MORGAN. Then you made a visit to Paris, did you not?

General HAINS. We made the visit to Paris first.

Senator MORGAN. Before you went there at all?

General HAINS. Yes, sir.

Senator MORGAN. There you entered into examinations into titles and plans and all that—the engineering and everything connected with this work they had been doing there?

General HAINS. We did not go much into the question of titles. We devoted our attention chiefly to the consideration of plans.

Senator MORGAN. Plans?

General HAINS. Plans; yes, sir.

Senator MORGAN. But you had it in mind that it might be possible that you could make a trade with the Panama Canal Company, or perhaps get a secession of Panama, or something like that; and at all events, there was an opportunity to get into possession?

General HAINS. A secession of Panama never entered my mind.

Senator HOPKINS. Mr. Chairman, I do not like to interrupt the Senator; but I can not see where that line of investigation is relevant. That is a closed incident, and I do not know why the time of the committee should be taken up with it. If it is a matter that the Senator himself wants information about it ought to be taken up at some time outside of the committee, it seems to me.

Senator MORGAN. As to the closed incident, as long as there is a heart in America that appreciates the honor of this country, that incident will never be closed from investigation and from free speech. I am not undertaking to get into the matter of secession, however; I made that remark humorously to the General, the idea being that they had in view at that time the acquisition of the property there by purchase or by some other method. I suppose that really no other method was contemplated; particularly not the method of capturing it from Colombia.

Senator HOPKINS. Well, Mr. Chairman, I for one protest against this line of examining the witnesses, because it is not pertinent to anything that we have before us as a committee; and as a legal proposition it is a closed incident.

Senator MORGAN. I was trying to apologize.

Senator HOPKINS. As a matter of historical reminiscence, it may be of interest to people that indulge in that, but for committee purposes it is not.

Senator MORGAN. I was trying to apologize, Mr. Chairman, for having, perhaps thoughtlessly, intruded upon the feelings of my friend here about this matter. But I will let that pass.

The CHAIRMAN. You may proceed, Senator, and we will see how we get along.

Senator MORGAN. I want to know whether you were invited to go to Paris by the Panama Canal Company or by any agent or person connected with it?

General HAINS. I do not think I was invited. I think I just made up my mind that I was going over there.

Senator MORGAN. But you went in a body?

General HAINS. Yes; we went in a body.

Senator MORGAN. There was some understanding, I suppose, that when you got there you would have an opportunity of investigating the affairs of the Panama Canal Company?

General HAINS. Oh, I think the authorities there had been notified that we were coming.

Senator MORGAN. How did that all come about? Who did it, and how was it done? How did it ever happen that there was any communication between you and the authorities in France about this United States Commission going over there to make an examination of this subject? Who brought it about, and how did it happen?

General HAINS. I do not know.

Senator MORGAN. Do you remember any communication from the director-general of the Panama Canal Company to the American Isthmian Canal Commission to go to Paris to examine into the situation there before you made an examination on the Isthmus?

General HAINS. I do not remember, but I think it is quite likely we had an invitation. I do not know. I can not say, now.

Senator MORGAN. Did you meet any agent of that canal company that was active and hospitable and influential and friendly and kind about getting these communications?

General HAINS. Oh, we had the chief engineer, we had the director, and—well, they were the two principal ones, and they had access to all the records, and they gave us all the information they could about it.

Senator MORGAN. Was there any American that was active in this business in getting you to go over there and providing hospitality, etc.

General HAINS. No, sir.

Senator MORGAN. No one at all?

General HAINS. Not that I know of. No, sir; I made up my mind that I was not going to report on that plan or on that route until I had gone to Paris and examined the records.

Senator MORGAN. That was before you had ever been on the Isthmus?

General HAINS. Oh, no, no; I had been on the Isthmus before, on a previous commission.

Senator MORGAN. A previous commission, yes; but I am asking whether it was before the Board ever went there?

General HAINS. That was before the Board went there.

Senator MORGAN. Now, the Walker Canal Commission, before they ever went to the Isthmus at all, went to Paris?

General HAINS. Yes, sir.

Senator MORGAN. And made an investigation there. What did they go there for?

General HAINS. To look at the maps, to see what the Frenchmen had in the way of records, papers, and all kinds of things. Then we wanted also—that was not the only object we had in going to Europe. We did not confine ourselves to a visit to Paris. We went and visited all the big canals there. We went to the Kiel canal, the Amsterdam canal, the Manchester Canal. All those were taken in in our examination. We wanted to get information.

Senator MORGAN. But you had distinctly in view the question whether or not you would ever recommend a canal at Panama? You had that distinctly in view, and you went to examine the Panama scheme?

General HAINS. We wanted to find out everything about it.

Senator MORGAN. Yes; and you had that proposition in view, that there was an expectation or a prospect that you would be authorized or required to recommend the Panama scheme to the United States Government? You had that all in view before you went there?

General HAINS. That there was a possibility that we might recommend the Panama route; yes, sir.

Senator MORGAN. How did you get that idea about it; from discussions with people, or just your own suggestions?

General HAINS. Why, the law required us.

Senator MORGAN. The law required you to go to Paris?

General HAINS. No, sir; it did not require us to go to Paris. It required us to report as to the most feasible and practicable route for a canal across the Isthmus.

Senator MORGAN. That was because you were engineers, and, I suppose, because the Congress of the United States desired to know what American engineers had to say about this American route; not about the situation in Paris. I do not remember that anything of that sort

occurred. Now, General, did you not go there because you knew that propositions were to be made for the transfer of that canal to the United States?

General HAINS. For that alone?

Senator MORGAN. I did not say "alone." Was that one of the reasons you went there—because you knew that propositions were to be made for the transfer of that canal to the United States?

General HAINS. I can answer that question in this way—that I did go there with an idea in my mind that possibly there might be a transfer of that property to the United States.

Senator MORGAN. Was that just a remote imagination of yours, or was it founded upon facts that you knew of in regard to a transaction of the kind?

General HAINS. It was founded on the fact that we were going to report as to which was the best route, because there were other routes besides Panama and Nicaragua, and we wanted to find out all about it; and we wanted to see the Kiel Canal, the Amsterdam Canal, and the Manchester Canal, and not alone to go to Paris.

Senator MORGAN. You did not have to go to Paris to see either the Kiel Canal or the Amsterdam Canal or any other canal?

General HAINS. No; but we—

Senator MORGAN. You went there to get information in regard to the Panama route?

General HAINS. Yes; we went there to get information in regard to the Panama route.

Senator MORGAN. And before the Commission had ever been to Panama?

General HAINS. Before the Commission as a body had ever been to Panama.

Senator MORGAN. I am trying to find out if I can, General, whether there was not at that time some proposition pending that would be agreeable to the French Government and agreeable to the Panama Canal Company by which the property was to be Americanized, or taken over by the United States.

General HAINS. Oh, I have seen that matter discussed in the papers, but I do not think that that was considered in the Commission. I do not remember of its being considered.

Senator MORGAN. Why did you not go to Colombia and ask her if she was willing that you should take the job off of the hands of the Panama Canal Company?

General HAINS. I do not know.

Senator MORGAN. That would have been a very nice thing to do, would it not—a very proper thing?

Senator HOPKINS. They had no authority for it, did they?

General HAINS. I do not know about that, either, Senator.

Senator MORGAN. You never thought about that. You knew that Colombia owned Panama at that time, did you not? She had granted the concessions for the canal?

General HAINS. I knew that the State of Panama was a part of the Republic of Colombia; yes, sir.

Senator MORGAN. And that Colombia had granted the concessions to the French Company?

General HAINS. Yes, sir; I knew that.

Senator MORGAN. And you knew that if you took it over at all it would be necessary to see Colombia about it, at some time or other, and in some fashion or other?

General HAINS. It would have been necessary to have made some arrangement with Colombia.

Senator HOPKINS. General, the facts were known to all the American people, were they not, just as well as to the Commission?

General HAINS. I think so. I think they were known to everybody.

Senator MORGAN. I must protest that I did not know them.

Senator HOPKINS. You may be an exception, then.

Senator MORGAN. I hardly think I am by many millions.

The CHAIRMAN. Senator, I did not know that there was anything in connection with that project down there that you were not informed about.

Senator HOPKINS. The general impression in this country is that he knows as much about it as anybody.

Senator MORGAN. I am in just the same situation as this committee is to-day, with a lot of suspicions in their minds and not any satisfactory information or the possibility, probably, of ever digging into it. That is the situation I am in.

Senator TALIAFERRO. General, when the Commission went to Paris, had a proposition been made to sell that French property to this Government?

General HAINS. I do not think it had, sir. I do not think it had been made by anybody. In fact, I am quite sure that it had not been.

Senator MORGAN. Did you know at that time of any American that had a right derived from the Panama Canal Company to sell that property to the United States, or to sell it to any syndicate that might be formed here?

General HAINS. No, sir; I did not.

Senator MORGAN. You did not hear of it?

General HAINS. No, sir.

Senator MORGAN. I am afraid they did not have confidence in you, General, such as I have. They were afraid to trust you. [Laughter.] However, you went there, and you were entertained there by the Frenchmen?

General HAINS. The Frenchmen gave us a dinner, and we gave them a dinner. We had that much entertainment, and no more.

Senator MORGAN. I am glad you had that much. Then you came back, and then you went afterwards to the Isthmus of Panama.

General HAINS. Oh, no; I did not come back.

Senator MORGAN. You went from there to the Isthmus?

General HAINS. Oh, to Panama—yes; I thought you meant to the other canals.

Senator MORGAN. No; you came back to New York, and then went down to Panama?

General HAINS. And then in December, I think it was, we went down to Panama.

Senator MORGAN. About what time did you get back from Paris, if you remember?

General HAINS. Let me see. I think we were over there altogether about six weeks.

Senator MORGAN. In Paris?

General HAINS. No, sir; we were between two and three weeks, I think, in Paris, and the remainder of the time was taken up in going to Kiel and examining the Kiel Canal, the Amsterdam Canal, and the Manchester Canal.

Senator MORGAN. Then, how long was it before you got down to the Isthmus again?

General HAINS. We left here, I think, to go to Paris about the latter part of July or the first of August, and we went to Panama about December.

Senator MORGAN. Yes, in December; and you spent about thirty or thirty-one days there?

General HAINS. No; we spent about three months there.

Senator MORGAN. At Panama?

General HAINS. On the Isthmus. No; we did not stay at Panama all the time. We went to Nicaragua first.

Senator MORGAN. I am not talking about Nicaragua; I am talking about what time you spent at Panama.

General HAINS. You asked me what time we left New York.

Senator MORGAN. Yes.

General HAINS. When we went south there we did not go to Panama alone; we went to these other places.

Senator MORGAN. I know; you went to Nicaragua first?

General HAINS. Yes.

Senator MORGAN. What I wanted to get at is when you arrived at Panama, as near the date as practicable, and how long you staid there.

General HAINS. I think we were on the Panama Isthmus something like about three weeks.

Senator MORGAN. That is my calculation; I think it is a little more than that. I think it was about thirty days.

General HAINS. I think perhaps it was. I do not remember exactly, but it was somewhere about that time.

Senator MORGAN. Now, during that time, after your arrival from Paris in New York and before you went down to Nicaragua and Panama, this subject of the taking over of the Panama Canal was publicly discussed in the newspapers, was it not?

General HAINS. Yes, sir.

Senator MORGAN. There got to be quite rife, active inquiry about taking it over?

General HAINS. I do not remember much about that, Senator. I know, just as a general fact, that the question was for us to report on the most feasible and practicable route, and Nicaragua and Panama were the two prominent ones. Then there were some others also.

Senator MORGAN. Did you meet Buneau-Varilla while you were in Paris?

General HAINS. No, sir; I never saw Buneau-Varilla until, I think, about the latter part of 1901, over here.

Senator MORGAN. Did you meet General Abbot over there?

General HAINS. Yes, sir.

Senator MORGAN. What was he doing there?

General HAINS. He at that time was a member of the technical commission of the French company.

Senator MORGAN. And you conferred with him about the canal situation, of course?

General HAINS. Yes, sir.

Senator MORGAN. He was then in the employment of the French Government, was he not, or the Canal Company?

General HAINS. I think he was.

Senator MORGAN. And he continued so for a long time?

General HAINS. My understanding was that he was at that time, and was continued for some time afterwards, but how long I do not know.

Senator MORGAN. Several years—two or three years?

General HAINS. I do not think as long as that, Senator; but still I do not know.

Senator MORGAN. You do not know?

General HAINS. No.

Senator MORGAN. Then when you got to Panama in your explorations this subject opened up, and it got to be a matter of very considerable interest, I suppose, to a good many people about whether the canal should be located at Panama or up here at Nicaragua. That was a great controversy at that time, was it not?

General HAINS. Yes, sir.

Senator MORGAN. Was that about the time that the *Oregon* doubled the Horn and came up to Santiago, or a little before?

General HAINS. Oh, that was afterwards.

Senator MORGAN. Yes—afterwards. Now, General, you were put upon this commission of execution or of work on the canal in April, 1905?

General HAINS. Yes, sir.

Senator MORGAN. You went down there and made an inspection of the work?

General HAINS. Yes, sir.

Senator MORGAN. How long after your appointment?

General HAINS. A little over three months.

Senator MORGAN. Was the yellow fever prevailing down there during that period of three months?

General HAINS. Yes, sir.

Senator MORGAN. And I suppose that was a reason, and a very good one, why the Commission did not want to go down there?

General HAINS. I do not know that the Commission were anxious to jump into a place where there was yellow fever, but I do not think the Commission were trying to shirk it, if it was proper for them to go.

Senator MORGAN. Well, they found plenty of work to do here?

General HAINS. Yes, sir; there was plenty of work. You see, Senator, when this new Commission was organized, it was organized on an entirely different basis from the old Commission.

Senator MORGAN. And with new material?

General HAINS. Nearly all new material. Before that the construction of the canal was confided to the Commission. Under the President's order pretty nearly all the duties were transferred to the chairman, the governor, and the chief engineer.

Senator MORGAN. I know there was a complete change in the programme of government and construction?

General HAINS. Yes; and the other four members became practically consulting engineers to the chairman.

Senator MORGAN. I understand that. I do not care about going into the particulars of the form of the reconstruction. I want to get at the fact that there was a reconstruction, new officers were put in,

including the Commissioners and a great many other additional officers, and that after your appointment, and after you had participated in arranging this new organization, you went down there to put it into effect, and that—

General HAINS. No, sir; I did not go down there for that purpose.

Senator MORGAN. I am not speaking of you personally; I am speaking about the Commission.

General HAINS. No, sir; the Commission did not go down for that purpose. I did not go down there with the Commission. I went down there along with Major Harrod in July, because Mr. Wallace had just resigned and had left things down there in such a condition that the Commission did not know exactly what the state of affairs was; and we had a meeting, and at the meeting it was ordered that Major Harrod and myself should go down there immediately and see what the conditions were.

Senator MORGAN. Mr. Wallace had not been a member of the Commission prior to April, 1905?

General HAINS. No, sir.

Senator MORGAN. He was put into the new Commission?

General HAINS. He was put in at the same time I was.

Senator MORGAN. And then he resigned somewhere about June?

General HAINS. The 1st of July, I think it was, or the latter part of June.

Senator MORGAN. The latter part of June or the first of July; yes.

General HAINS. Yes.

Senator MORGAN. And then you went down there with Mr. Harrod for the purpose of looking at the situation and seeing how everything was getting on, what work was being done, and all about it, and to examine the situation?

General HAINS. To try to find out what had been done.

Senator MORGAN. Yes. Now, I want to take the period when you went there—that is what I want to get at—and to ascertain from you, by comparisons with the situation that existed there at the time you made your first visit, as to what work had been done by the first commission of construction, headed by Admiral Walker?

General HAINS. In starting a great work like that, Senator, there is a great deal that has to be done, and a great deal had been done. At the time we were there, so far as you could see on the surface, there was not much difference in the amount of work done; but there had been an organization perfected, and they had gotten to work and had excavated something like 800,000 to 1,000,000 cubic yards of material out of the Culebra Cut.

Senator MORGAN. This first Commission?

General HAINS. The first Commission had; yes, sir. Now, those figures, Senator, are just rough figures. I may have over-estimated that; I think perhaps I have.

Senator MORGAN. I know; but the reports will show what it was?

General HAINS. Yes.

Senator MORGAN. That work was really premature, was it not? The condition of the other parts of the establishment between Colon and Panama was not such as to justify going regularly to work and digging out the Culebra Heights? It would have been just as well if that work had been omitted, would it not?

General HAINS. I think it would have been a great deal better if they had not undertaken it at all.

Senator MORGAN. But you remember an outcry, do you not, in the country here, about "making the dirt fly?"

General HAINS. Yes.

Senator MORGAN. You remember that?

General HAINS. Oh, I have seen it.

Senator MORGAN. You remember the pledges of some great, leading members of the Cabinet that we were going to work to "make the dirt fly?"

General HAINS. I do not know who did it, Senator; but I know that I have heard of "flying dirt."

Senator MORGAN. We all know, except you, who made it. Now, was there not, General, a very great pressure in this country to have that digging going on at once and very rapidly while this first Commission were merely making preparations, or trying to make preparations, to conduct the work successfully and economically? Was there not very great pressure about it?

General HAINS. I think a great many people had an idea that all they had to do was to send out a lot of people there and fling the dirt out of a ditch, and get the canal built quickly in that way.

Senator MORGAN. And that was in fact the last work you had to do after you got ready for it?

General HAINS. I think there ought to have been about two years spent in preparation.

Senator MORGAN. Two years?

General HAINS. Yes, sir.

Senator MORGAN. Now, General, in the way of preparation, except the diversion of this work into the Culebra Cut, did you see any want of diligence or attention or enterprise amongst the Commissioners or their employees in what they had been doing down there? Did you find that they had been loitering and disregarding their work, or anything of that kind? I refer to the old Commission that preceded you.

General HAINS. No, sir; I can not say that I saw any evidence of neglect on the part of the old Commission.

Senator MORGAN. Or of any of their employees?

General HAINS. No; I do not think on the part of any of the employees, either.

Senator MORGAN. Did you hear any accusations brought by anybody against the old Commission to the effect that they were not devotedly performing their duty there in trying to put that work on its feet so that it could be done in a rational way?

General HAINS. I saw all kinds of statements in the papers, you know, Senator; that is about all. I never saw anything else, or never heard of anything else, except reports in the papers; that is all.

Senator MORGAN. Those reports, as of course we know, are not predicated upon a knowledge of the situation.

General HAINS. No, sir; they are not.

Senator MORGAN. And therefore they were either mistakes or else misrepresentations. Now, do you know of any cause, affecting all or any of the members of the first Commission, for their removal?

General HAINS. Cause for removal of the members of the Commission?

Senator MORGAN. Yes; all of them or any of them?

General HAINS. I do not see how I could very well, Senator, become acquainted with any cause for that; because, you know, I had nothing to do with the Commission. I was only a citizen of the country..

Senator MORGAN. You were a Commissioner, of course?

General HAINS. No; not at that time.

Senator MORGAN. But I mean when you went down there to make this inspection.

General HAINS. Oh, yes.

Senator MORGAN. Yes, sir; and you were looking over what had been done?

General HAINS. Yes.

Senator MORGAN. As it was your duty and your right to do; and you had a right to make the most intimate inquiries in regard to every man who had been at work there, to know whether he had done his duty or not. Did you meet with any accusations against any man of an important character—I am talking about men who controlled the work—as to their delinquency or their want of efficiency in conducting that work?

General HAINS. I do not remember of any.

Senator MORGAN. If such things had occurred they certainly would have impressed your mind?

General HAINS. Yes; I think so.

Senator MORGAN. Because they would have been very serious matters. So that so far as you know or could discern or see there was no dereliction of duty that was visible, if I understand you correctly, and you did not know of any accusations that were brought against that Commission or any member of it that required that they should be removed from the public service?

General HAINS. No, sir.

Senator MORGAN. Were their resignations voluntary or were they required; do you know?

General HAINS. I do not know.

Senator MORGAN. They made no complaint that you heard of about being removed?

General HAINS. No, sir.

Senator MORGAN. And none of them ever evinced any dissatisfaction with the action of the Government in removing them, so far as you know?

General HAINS. No; I do not know of their doing so.

Senator MORGAN. So that so far as you knew or were informed, there was no known cause for the change of the Commission?

General HAINS. No; I did not know of any cause.

Senator MORGAN. You found that that old Commission, the first Commission, had prepared a very ample code of statute laws for the Zone?

General HAINS. I can not say that I know much about the laws that they prepared, Senator.

Senator MORGAN. You have seen the book, have you not?

General HAINS. Yes; I have seen the book, but I have not read the book.

Senator MORGAN. You have not read it?

General HAINS. No, sir.

Senator MORGAN. So you do not know what the laws of the Zone are?

General HAINS. No, sir; I do not know what the laws are. I do not consider that I have anything to do about the government of the Zone on this Commission. I have nothing to do with anything except the engineering matters.

Senator MORGAN. That is, since you have been in there?

General HAINS. Since I have been in there.

Senator MORGAN. And you have not put yourself to the trouble of trying to find out what other departments there had been engaged in doing?

General HAINS. No; not specially; no, sir.

Senator MORGAN. I have read that code of laws, and I am supposed to be a lawyer, and I think it is a very highly commendable body of statute laws, and it must have taken a great deal of work and a great deal of wisdom, too, to have enacted that body of laws for a perfectly new situation. That is the reason why I asked you about the government of the Canal Zone. At the time that this Commission took charge of the property there, the Zone, and before that time, if I understand the situation—and I want to see if you understand it as I do—the civil and criminal laws that governed there were the laws of Colombia?

General HAINS. Yes, sir.

Senator MORGAN. Or the police laws of the State of Panama?

General HAINS. Yes, sir.

Senator MORGAN. And that entire system had to be substituted to meet new conditions?

General HAINS. Yes, sir.

Senator MORGAN. That became the Government of the United States?

General HAINS. Yes, sir.

Senator MORGAN. They adopted some of the old Spanish laws that were remaining there, to get along with them until they could substitute them with laws that were better. It has always occurred to me that that was a very great labor, and it was well performed. Since you have been a Commissioner, in whose charge has the conduct of the railroad been?

General HAINS. The Panama Railroad Company?

Senator MORGAN. Yes; the Panama Railroad Company. You were one of the directors?

General HAINS. Yes, sir.

Senator MORGAN. Did you ever participate in any of the meetings?

General HAINS. Yes, sir.

Senator MORGAN. And took your part of the work of directing the work of that railroad company?

General HAINS. Yes, sir.

Senator MORGAN. Who are the chief men that control it, besides the directors?

General HAINS. The president of the road and the superintendent or chief engineer.

Senator MORGAN. Who was the superintendent?

General HAINS. The chief engineer of the canal, Mr. Wallace; I think he was the superintendent during the time he was there, and Mr. Stevens has been since.

Senator MORGAN. Mr. Shonts has never been? He was president of the road?

General HAINS. Mr. Shonts is president of the road.

Senator MORGAN. They have a president and a general superintendent?

General HAINS. I believe that is his position—general superintendent.

Senator MORGAN. What body of men was it—the Canal Commissioners or the railroad directors—that prescribed the freight rates, for instance, for that railroad?

General HAINS. Oh, that was some officer of the company. I did not have anything to do with that.

Senator MORGAN. If you ever prescribed any freight rates as a Commissioner, you did not know it?

General HAINS. No, sir.

Senator MORGAN. Who had the direction of the purchase of the ships or the acquiring of ships in addition to those that belonged to the railroad under charter parties?

General HAINS. That matter was considered by the board of directors.

Senator MORGAN. Of the railroad?

General HAINS. Yes, sir.

Senator MORGAN. What part or function does that railroad perform in the actual work of carrying this canal into successful operation?

General HAINS. The railroad?

Senator MORGAN. The railroad.

General HAINS. Oh, it is an absolute necessity. It is like any tool for doing a piece of work; you could not do it without it.

Senator MORGAN. Therefore, during the time since the thing has been in operation it was the prime factor in the work?

General HAINS. Yes, sir.

Senator MORGAN. And the direction of the railroad, therefore, was quite as important a matter as the direction of the work on the canal?

General HAINS. Yes; to some extent.

Senator MORGAN. You got all your material from the railroad from abroad—all that was imported?

General HAINS. I had nothing to do with the procuring of material.

Senator MORGAN. No; you had not anything to do with it, but you have a general knowledge of the fact that all the material was imported there through the assistance of the railroad and its ships?

General HAINS. Oh, you mean carried down there?

Senator MORGAN. Carried down there to the place.

General HAINS. Oh, yes; yes.

Senator MORGAN. And of course the transportation—

General HAINS. But, Senator, allow me: I think perhaps that is so as to a large amount of it; but there was quite a good amount also which was taken down there on other vessels, outside of the vessels in the employ of the Government.

Senator MORGAN. A great amount of it, of course; but the railroad was still an indispensable factor in supplying material and men and provisions and everything else to that canal work?

General HAINS. Yes, sir.

Senator MORGAN. Did you ever sit as a Commissioner upon the investigation of a claim brought by the New Panama Canal Company against the United States for a sum somewhat above two millions of dollars?

General HAINS. Did I ever do what about it?

Senator MORGAN. Did you ever, as a Commissioner, sit in judgment or in inquiry upon the examination of such a claim as that?

General HAINS. No, sir.

Senator MORGAN. You have seen the examination on the minutes of your Commission, have you not?

General HAINS. Yes, sir.

Senator MORGAN. You have seen that?

General HAINS. Yes, sir.

Senator MORGAN. Did all that occur before you became a Commissioner?

General HAINS. Yes, sir.

Senator MORGAN. Is it still pending, undecided?

General HAINS. I so understand; I do not know. I suppose it is still pending. Yes, I am quite sure that it is still pending.

Senator MORGAN. That claim is still pending and undecided?

General HAINS. Undecided.

Senator MORGAN. It covers, if I understand it right, work done on the canal between the time that the first offer was made by Monsieur Bo in behalf of that canal company to sell the property and the time of the turning over of the property under the Hay-Varilla treaty. That is the period of time that was covered by this claim, in my understanding. Do you understand it that way—that it is for the work done between those two periods of time upon the canal?

General HAINS. I think the idea is to go back further than that with that claim, Senator.

Senator MORGAN. How far back?

General HAINS. Oh, I think they claim away back until some time when they believed we made our first estimate. That would be some time in 1899.

Senator MORGAN. Yes; I think you are right about that—when they supposed or believed that you had made your first estimate?

General HAINS. Yes, sir.

Senator MORGAN. Which, when summed up, amounted to forty millions of dollars?

General HAINS. Yes; we summed up that it was worth \$40,000,000.

Senator MORGAN. I will just call one item to your attention. That estimate included the removal of the railroad line from one side of the country there to another, did it not? That estimate included compensation to the Panama Canal Company for having transferred the track and removed it from one side of the Chagres River, I will say, to the other?

General HAINS. Oh, I think there is included an item of \$300,000 for a diversion of the railroad.

Senator MORGAN. Yes.

General HAINS. But that is only for a little piece of it—a small piece of it.

Senator MORGAN. I know it is a small piece of it; but it cost a great deal.

General HAINS. Yes; but it was not—

Senator MORGAN. Well, that item was in it?

General HAINS. It was to get the road around Culebra hill.

Senator MORGAN. Yes. Why was that?

General HAINS. The road was located somewhat farther to the eastward before that, and it was removed so as to get around back of the hill and cross near the reservoir that has been built there for the water-supply of the city of Panama.

Senator MORGAN. The point I want to get at is this: That all of that diversion of the railroad had been made before you went down there to make your examination, had it not?

General HAINS. I can not say.

Senator MORGAN. You do not know whether it was before or since?

General HAINS. No, sir; I do not know. No; I do not think it was, Senator. I do not think it was.

Senator MORGAN. It was before any agreement was made or accepted between the United States or any of its agents and the Panama Canal Company for the purchase of the property of the canal company?

General HAINS. I can not say that positively, either.

Senator MORGAN. You do not know?

General HAINS. No; I do not know.

Senator MORGAN. That diversion was not made after the first Walker Commission of construction took possession? It was made before that time, was it not?

General HAINS. Yes, sir.

Senator MORGAN. Now, that was made necessary—I want to get your opinion about that—by the work that was being done by the Frenchmen in building that canal through Culebra Heights?

General HAINS. Yes, sir.

Senator MORGAN. It was a part of the necessity of the work that they were conducting at Culebra Heights that made it necessary to make this diversion of a part of the track around that hill, to put it on the other side of the hill, if I understand it?

General HAINS. Yes; but it would have been the same thing if anybody else was doing the same work, Senator.

Senator MORGAN. But they were doing it for themselves?

General HAINS. At that time I think they were.

Senator MORGAN. They were not doing it under any obligation or promise or suggestion of the United States?

General HAINS. No, sir.

Senator MORGAN. I have always been curious to know why that \$300,000 item was put into that \$40,000,000.

General HAINS. That \$300,000 item was put in there because that diversion we considered as necessary to be made.

Senator MORGAN. And if they had not made it, you would have had it to make?

General HAINS. If they had not made it, we would have had to make it.

Senator MORGAN. It is equally necessary to dig the canal out from Bohio to the seaboard, is it not?

General HAINS. Yes; but if they had done it, I think we ought to have paid them for it.

Senator MORGAN. You think the diversion being put in there to facilitate the work on the Culebra Heights was something that the United States ought to pay for, although it was done before we took possession or had any right to the property at all?

General HAINS. If they are entitled to pay for the work that they did after any specified date that might be agreed on, it seems to me

that they ought to be paid also for that diversion if that was done subsequent to that same date.

Senator MORGAN. Well, they had bought, after the others had built it, the entire railroad line through from shore to shore or the stock in it. Was it necessary, because they had done that work, that the United States should pay them for betterments put upon it?

General HAINS. I do not know about the betterments; but, Senator, we paid them for the Panama Railroad itself.

Senator MORGAN. We paid them for the stock; we bought the stock.

General HAINS. We bought the stock, but we did not care anything about the stock itself. What we wanted was the railroad.

Senator MORGAN. But you could not get the railroad without the stock.

General HAINS. That is very true.

Senator MORGAN. Yes. Now, in buying up the stock and paying them in full what they asked for it, whatever it was (\$8,000,000 or \$10,000,000 or \$18,000,000, whatever it might have been), we paid for all that; we paid for all the betterments and all the improvements and everything else that had been done there when we bought the stock. That being so, after buying the stock and paying for it, can you exactly see light through the proposition that we ought also to pay for the betterments they put there in transferring this road from one place to another?

General HAINS. If the French company's proposition had been accepted before that diversion had taken place the whole cost of this would have fallen on the United States.

Senator MORGAN. But it was not. That is exactly what did not happen, and after that we bought the entire property by buying the stock.

General HAINS. I am of the opinion, although I can not state positively about it, that this diversion of the railroad was being made at this very time, Senator—at the time that we made this estimate.

Senator MORGAN. It was being made at that time?

General HAINS. Yes; I think it was then being made.

Senator MORGAN. It was made for their own convenience, was it not?

General HAINS. Well, yes.

Senator MORGAN. It was made in their effort to work out the canal plan that they were bound to make good to Colombia?

General HAINS. Yes; it was being made for them.

Senator MORGAN. They had a contract with Colombia for the construction of that canal? That is to say, they had a concession?

General HAINS. Yes.

Senator MORGAN. And Colombia had a very great interest in it. At the end of ninety-nine years it was all to go to Colombia, every bit of it, was it not?

General HAINS. Yes.

Senator MORGAN. And of course they were doing it in order to facilitate their own work in holding on to their concession. Now, General, was not the work that they were doing there at the time that you saw them at work during these thirty days that you spent on the Isthmus palpably work that was being done in a perfunctory way in order to hold on to their concessions from Colombia?

General HAINS. I could only express an opinion on that point.

Senator MORGAN. That is exactly what I want.

General HAINS. Well, it looked that way.

Senator MORGAN. Yes; it did not look any other way, did it?

General HAINS. I think my answer is about all I can say about it. It looked as though it was being done in a perfunctory way for the purpose of keeping alive the concession.

Senator MORGAN. You had no doubt about what they were doing there and that that was exactly what they were doing—they were working to keep the concession alive?

General HAINS. I guess that was it. I do not know positively, Senator; but it looked that way.

Senator MORGAN. At the rate of work that they were doing at the time you first saw that work there, when you went down with the Commission, how long would it have taken them to have completed a lock canal?

General HAINS. At that rate of work?

Senator MORGAN. Yes.

General HAINS. Oh, I think they could have finished it in the course of fifty or seventy-five years.

Senator MORGAN. Yes, I expect they would; but the concessions would have been dead forty-five or fifty years before they got through it, and Colombia would have had it all. That was the situation they were in.

Now, while they were doing this work on Culebra Heights they were permitting the prism of the canal that they had dredged out to fill up, without taking any care of it at all? Was not that the situation?

General HAINS. I think that is correct.

Senator MORGAN. That was correct between Bohio and Colon, and it was also correct between Miraflores and Boca Rio Grande?

General HAINS. Yes; yes.

Senator MORGAN. I do not think I have any more questions to ask the witness.

Senator TALIAFERRO. General Hains, you have spoken several times in your examination about an estimate. Do you understand that that property was bought on an estimate of its value, or for a round sum?

General HAINS. Do you mean the Panama Canal?

Senator TALIAFERRO. Yes.

General HAINS. All I know is this, Senator: We undertook to determine the value of that property of the canal company, and we thought it was worth fully forty millions of dollars, based on the estimated quantities of work done that would be of value in the plan of the canal that we were going to recommend, and other things in connection with it; we thought it would be worth fully forty millions of dollars.

Senator TALIAFERRO. Was that estimate or not solely and entirely for the information of the Commission and of this Government?

General HAINS. It was entirely for the information of this Government.

Senator TALIAFERRO. So that our purchase of that property for forty millions of dollars was without any obligation whatever on our part to pay any more than \$40,000,000 for it?

General HAINS. Yes, sir. Now, let me say one thing there, Senator. We estimated the value of the canal property at \$40,000,000. The French company, when they made a proposition (it was a long time

before we could get them to do it) when they did make a proposition, they wanted \$109,000,000.

Senator MORGAN. One hundred and nine millions?

General HAINS. Yes, sir.

Senator MORGAN. Yes, that is my recollection.

General HAINS. Then, afterwards, after the bill for the construction of the canal, I think it was on the Nicaragua route, had passed the House of Representatives, they made this offer—"Here, take this canal at your own figure."

Senator MORGAN. That was the first Hepburn bill, was it not?

General HAINS. I believe it was the first Hepburn bill.

Senator TALIAFERRO. They offered what?

General HAINS. They offered then to the United States everything they had for just what we valued it at.

Senator MORGAN. Forty millions of dollars?

General HAINS. Forty millions of dollars. Now, that came as a proposition from the French company.

Senator TALIAFERRO. Let me ask you right there, General—if you know about it—did they not remove Monsieur Hutin, who was the director-general of that canal company, from office, and put Monsieur Bô in for the express purpose of making that drop?

General HAINS. That I can not say, Senator.

Senator TALIAFERRO. Did the French company offer to sell that property to this Government at what your Commission estimated it to be worth, or did they offer to sell it at \$40,000,000?

General HAINS. I think the thing was put something like this: "Take the canal and everything we have there for your own valuation. You estimated it was worth forty millions. Take it at forty millions." That is the way I understood it.

Senator TALIAFERRO. So that, whatever the circumstances may have been, the French company understood that they were to receive forty millions of dollars for that property—no more, no less?

General HAINS. That is the way I understood it.

Senator TALIAFERRO. So that there is no obligation on the part of this Government to pay anything in excess of the forty millions that have been paid?

General HAINS. I do not think there is any obligation other than that, perhaps, of an equitable amount for work they did subsequent to the time that we accepted their proposition.

Senator MORGAN. If you will allow me, if there is any such equitable sum, is it not set off by another equitable allowance in favor of the United States for filling up that they permitted to go on there—the dilapidation of their property?

General HAINS. Not the dilapidation of the property, Senator, in that sense—the dilapidation of the property—you might say the filling up of the canal, though I do not think there was much more of that; but so far as the property was concerned (I am speaking now of the movable property—the plant) we did not attach any value to it at all in our forty millions. When we made the estimate of forty millions of dollars we did not consider that there was a locomotive or anything there that was worth anything.

Senator TALIAFERRO. What work have they done since their offer to sell that property to us was accepted by this Government?

General HAINS. There comes up a question of law that I am not capable of dealing with. Their offer was accepted, I understand, on the 3d of March, 1903, subject, however, to the ratification of a treaty between the United States and Colombia to enable the United States to step in and take possession.

Senator TALIAFERRO. And the United States took possession just as soon as satisfactory treaty arrangements were made?

General HAINS. Yes, sir.

Senator TALIAFERRO. Where have they any claim on that score, if it was subject to the ratification of this satisfactory treaty? You say the purchase was made subject to the ratification of a satisfactory treaty.

General HAINS. It seems to me it is a question of equity altogether. The French company, after they had made their proposition to us, gave us a certain time in which to accept it. I think it was an option that would expire on the 3d of March, 1903.

Senator KITTREDGE. Was not that option extended?

General HAINS. I do not know. I did not have anything to do with the canal after that, so that I do not know much about it; but as I understand it, I think the Attorney-General accepted the proposition on the 3d of March, subject to these conditions.

Senator TALIAFERRO. Subject to satisfactory treaty arrangements?

General HAINS. Yes, sir.

Senator MORGAN. I had a document printed yesterday and referred to this committee that I got from the Attorney-General, setting forth all of the propositions and all of the agreements; so we have the official status upon that question.

Senator TALIAFERRO. In negotiating the purchase of that property, through whom were the negotiations conducted on the part of the French company? Who represented the French company in the negotiations?

General HAINS. I do not know that I can answer that question from my own knowledge. During a part of the time I know that Mr. Hutin, the director, was in negotiation either with the Commission or with the chairman of the Commission; and subsequently he was removed, or subsequently Mr. Bo was made director, and I think the matter was consummated by Mr. Bo, assisted by Mr. Lampré. Mr. Lampré, the secretary of the company, was in Washington a part of the time when these negotiations were going on; but I had very little to do with it at the time. In fact, I did not have anything to do with it, and I only know that these things were going on as a matter of common knowledge to anybody that might be around the Commission's office. I was not getting any pay as a member of the Commission at that time.

Senator TALIAFERRO. You are a member of the Commission now?

General HAINS. Yes, sir; I am now.

Senator TALIAFERRO. And you say this claim for something over two millions of dollars, this claim of the French company for additional compensation, is now pending in the Commission?

General HAINS. I do not understand that it is pending in the Commission; no, sir.

Senator TALIAFERRO. Has it not been presented to the Commission?

General HAINS. It was presented to the Commission, and the Commission acted on it about a year and a half ago.

Senator TALIAFERRO. What action did the Commission take?

General HAINS. I think the action of the Commission was adverse; but they have not given up all idea of working the claim through, notwithstanding.

Senator TALIAFERRO. Did you coincide with the decision of the Commission?

General HAINS. I never went into that subject, Senator.

Senator TALIAFERRO. You were not on the Commission at that time?

General HAINS. No, sir; I was not on the Commission at that time, and I do not know enough about it to justify me in expressing an opinion. I would rather not express an opinion.

Senator TALIAFERRO. Has the claim been presented to the present Commission?

General HAINS. To this existing Commission?

Senator TALIAFERRO. Yes.

General HAINS. No, sir; not that I know of. I think it is now a matter of arbitration in some way.

Senator TALIAFERRO. In what way?

General HAINS. I do not know.

Senator TALIAFERRO. Who is to arbitrate it?

General HAINS. I think they have asked the President to do so.

Senator TALIAFERRO. Through whom?

General HAINS. I was called before the Assistant Attorney-General a few days ago to give my testimony, or to give my recollection of how those estimates were made up, and that was with a view to its effect on this claim. I understood that they had agreed to let it be determined by the President whether they are entitled to anything or not, just as a matter of equity. Of course that would not give them the money.

Senator TALIAFERRO. When you say "they" have, you understand, agreed to leave it to the President, who do you mean?

General HAINS. I mean the representatives of the canal company.

Senator TALIAFERRO. The French company?

General HAINS. Yes, sir.

Senator TALIAFERRO. Who are they?

General HAINS. Cromwell & Sullivan, I think, is the name of the firm.

Senator TALIAFERRO. You say you were called before the Assistant Attorney-General recently in connection with this case?

General HAINS. Yes, sir.

Senator TALIAFERRO. What was his name?

General HAINS. Charles H. Russell, I think his name is; Mr. Russell.

Senator MORGAN. Was it Mr. Russell you appeared before to give your statement?

General HAINS. Mr. Russell and Mr. Hill. Mr. Russell represented the United States. Mr. Hill, I understand, represented the canal company in the capacity of a member of the firm of Cromwell & Sullivan.

Senator MORGAN. That was just a few days ago?

General HAINS. Yes, sir.

Senator MORGAN. So the matter is pending yet?

General HAINS. That is the reason, I suppose, it is pending.

Senator MORGAN. Of course, they would not have asked you unless there had been some matter pending.

Senator TALIAFERRO. You gave your statement, General Hains, I understood you to say?

General HAINS. Yes, sir.

Senator TALIAFERRO. Was the question of this option given to the United States in connection with the purchase of that property discussed in your investigation?

General HAINS. In what?

Senator TALIAFERRO. In your investigation by the Attorney-General?

General HAINS. I do not know that I exactly understand your question, Senator?

Senator TALIAFERRO. The French company gave this Government an option for the purchase of that property?

General HAINS. Yes, sir.

Senator TALIAFERRO. I say, was the question of that option discussed in your examination by the Attorney-General?

General HAINS. I do not think the question of that option was discussed, exactly. It was more a question of the time our estimate was made, and how we came to make it forty millions of dollars. That is what it was about—the time when we made it, and how we made it, what we based it on.

Senator TALIAFERRO. You are quite clear that your Commission fixed this price of forty millions, instead of the French company?

General HAINS. Oh, it is in our report; we fixed it at forty millions of dollars. I can show you where it is in our report.

Senator MORGAN. Perhaps I can refresh your memory about that.

Senator TALIAFERRO. I would like to have you read it. Just read it, General.

General HAINS. This is the report of the Commission of 1899–1901 [reading]:

“The quantities given in the foregoing estimate are based upon the present condition on the Isthmus, utilizing the excavations already made where they are useful. The new company has excavated about 5,000,000 cubic yards”——

That is, altogether; it is what the new company had done in several years [reading]:

“Which, added to the 72,000,000 cubic yards excavated prior to its organization, make a total of 77,000,000 cubic yards excavated by the two companies. Much of it is of no value because of the various changes of plan. For example, sites for locks have been excavated and then abandoned; the spoil banks on the Atlantic maritime section frequently come within the limits of the canal prism now projected, and must be rehandled. The amount of work done which will be of value under the plan recommended by the Commission has been carefully computed for the main canal line, and is found to be 36,689,965 cubic yards.

“The amount of excavation which can be utilized in the Chagres diversion is 210,873 cubic yards, and in the Gatun diversion 2,685,494 cubic yards. Adding these together, the total quantity of excavation which will be of value in the new plan is 39,586,332 cubic yards. A temporary diversion of the Panama Railroad has been made at the Culebra Cut, which also must be considered. Using the same classification of materials and the same unit prices as in the other estimates,

with the 20 per cent added for contingencies, the value of the work done is found to be:

Canal excavation.....	\$21,020,386
Chagres diversion	178,186
Gatun diversion	1,396,456
Railroad diversion (4 miles)	300,000
	<hr/>
	22,895,028
Contingencies, 20 per cent.....	4,579,005.

Senator MORGAN. That was just added to the price?

General HAINS. We explain that after awhile, Senator; it comes in later.

Senator MORGAN. All right.

General HAINS. Making an aggregate of \$27,474,033 [reading].

"There is on hand an immense amount of plant, consisting of locomotives, excavators, dredges, cars, rails, and machines, implements, tools, spare parts, and supplies of various kinds, besides buildings used for offices, quarters, storehouses, hospitals, and miscellaneous purposes, and some 30,000 acres of land. The inventory furnished to the Commission includes many thousands of items, classified as follows:"

Then comes in lands, buildings, and so on.

Senator TALIAFERRO. Yes; you need not read that.

General HAINS (reading): "As a general rule, this property shows signs of attention, and the evidence seems satisfactory that it has been well cared for since the liquidator took charge of it in 1889. It would manifestly be imprudent, however, to fix a value upon any important machine which has been idle that length of time without first actually testing it at work, however neatly painted and sheltered it may now be. Much of the property is ill adapted to American methods, and all of it is now from thirteen to twenty years old, during which period the improvements in this class of machinery have been such that contractors would generally find it to their advantage to buy entirely new machinery of modern pattern rather than attempt to use this of an older class, even if given to them free and in good order.

"The locomotives, rails, and cars may be of some service, but their value is doubtful; the locomotives are much lighter than is desirable for economical service, the rails are of a pattern ill fitted to rough use, and the cars have narrow-tread wheels. The cars are probably the best part of the whole outfit. It has seemed to the Commission that in acquiring the Panama Canal the United States should not buy this plant as a whole, and that no special allowance should be made for it in estimating the total value of the property. Its owners may realize something by the sale of portions of it to contractors if the latter find that they can use it to advantage. This valuation is all that the Commission can put upon the plant; it has already appeared in the estimates, since the unit prices have been fixed upon the condition that contractors furnish their own plant."

Now, there is a paragraph about the value of buildings and another one about the value of concessions and lands. Shall I read them?

Senator TALIAFERRO. You need not read those. Just go to your summing up.

General HAINS. The summing up is:

"The existence of the Panama Railroad is, however, a very important factor, as it supplies a service railroad for the entire length of the

canal. On the basis of \$75,000 a mile, this railroad would be worth \$3,500,000, which is half the face value of its capital stock. In view of its good condition and its valuable termini, it should not be estimated for purposes of canal construction at less than \$6,850,000, the par value of the 68,500 shares of its stock held by the canal company. The exceptional gage—5 feet—somewhat reduces its value, as it adds to the cost of rolling stock. The maps, drawings, and records are unusually complete and their value is great, though not capable of accurate estimate. In the judgment of the Commission a fair allowance for these would be \$2,000,000.

“Summing up the foregoing items, the total value of the property is found to be:

Excavation already done	\$27, 474, 033
Panama Railroad stock at par.....	6, 850, 000
Maps, drawings, and records.....	2, 000, 000
Total.....	36, 324, 033

“To which add 10 per cent to cover omissions, making the total valuation of the Panama Canal \$40,000,000.”

Senator MORGAN. That 10 per cent has been added in before on the digging.

General HAINS. Oh, that 10 per cent for the digging, Senator, is correct; but this last part was not for digging.

Senator MORGAN. That has been added in before, and it is put in again?

General HAINS. Oh, no; no, sir.

Senator MORGAN. That is the way I understand it.

General HAINS. Oh, no; you are wrong there.

Senator MORGAN. Here is so much digging done on these various items that you have mentioned, so many cubic yards ascertained that are useful to the United States?

General HAINS. Yes, sir.

Senator MORGAN. And that is summed up at a certain sum of money as being the then present value of it. Why do you add 20 per cent to that?

General HAINS. We undertook to estimate the cost of excavation there at certain unit prices. There was a certain amount for dredging, a certain amount for dry excavation, a certain amount for rock under water (\$4.75 for the latter), and all that sort of thing. Then, after that, we added 20 per cent for contingencies. In order to make the estimate—

Senator MORGAN. But there were not any contingencies about work that had already been done.

General HAINS. Yes; but, then, there were all kinds of things that were covered in that. We were taking it on the basis of our own estimates, and in all our estimates for computing the cost we always added 20 per cent for contingencies.

Senator MORGAN. How about the contingencies put on the two millions of dollars with reference to maps? They were already completed.

General HAINS. Yes; but we state in there that they are not susceptible of accurate estimate. I think they were very cheap.

Senator MORGAN. Really, then, the 20 per cent estimate for contingencies was put on in order to make a liberal allowance?

General HAINS. I do not think it was for that, Senator. That estimate was made up, and it was found that it amounted to very nearly forty millions of dollars. It is not exactly forty millions of dollars; you put 10 per cent in and it will not make forty millions of dollars.

Senator MORGAN. I know there is a gap to be filled in, and I do not know how it ever was filled.

General HAINS. But we made it pretty nearly forty millions of dollars, and we simply said, "Well, we will call it forty millions of dollars."

Senator MORGAN. Yes.

General HAINS. And we were satisfied that that was a very low estimate. I am satisfied that it was a very, exceedingly low estimate.

Senator TALIAFERRO. That report was made in 1901.

General HAINS. Yes, sir; I think in November, 1901.

Senator TALIAFERRO. If your idea is that that property was purchased with some reference to your estimate as to its value, why has there not been added to the price the outlay by the French company since this report was made, since 1901?

General HAINS. I think that is the question that is up—that is what constitutes the claim.

Senator TALIAFERRO. Covering that time from 1901?

General HAINS. Well, I do not know; I think they go back a little further than that. They want to claim back as far as 1899, when we made our estimate. They want to get back to the date when we made the estimate from certain cross sections that they gave us.

Senator MORGAN. Going back to 1899 was probably due to the zeal of the counsel representing the claim and wanting to make it as large as possible; and representing the United States at the same time, they had the thing pretty much in their own hands, or they thought they had.

Now I want to call your attention to the fact that when Mr. Bo cabled to the French embassy here and told them to accept the estimate of the United States, as stated in the report of the Commission upon the pages which you have just now read, they made the proposition to accept the estimate as made on those pages of that report. You remember that, do you not?

General HAINS. I do not remember, Senator; no.

Senator MORGAN. I have the record of it here to show that from the Attorney-General.

General HAINS. That settles it better than I could remember it.

Senator MORGAN. So that question is all settled by the record. Has Mr. Cromwell ever talked this subject over with you?

General HAINS. I do not think I ever had any conversation at all with Mr. Cromwell about it.

Senator KITTREDGE. Did you with Mr. Hill?

General HAINS. I did, a few days ago. He came and asked me about it and asked me if I would go up before the Assistant Attorney-General and allow them to ask me some questions about it, and that is what I did.

Senator KITTREDGE. Did you talk with him regarding the statement that you should make?

General HAINS. I did not go up with him, but I went up there and met him there and met Mr. Russell there.

(By request of Senator Kittredge, his question was read aloud by the stenographer, as follows:)

"Did you talk with him regarding the statement that you should make?"

General HAINS. He asked me what my memory was about it, and I told him what I remembered about it, and he seemed very much disappointed that my memory did not—

Senator MORGAN. General, have you ever found out, or do you know, how that gap was filled up between the forty millions of dollars and the smaller sum that was added up as the calculation of the value of what we were getting from the Panama Canal Company?

General HAINS. That estimate, Senator, was gotten up by the Panama committee. The Commission consisted of nine members; and that committee, which had special care of the study of all matters pertaining to the Panama route, consisted of three members—General Ernst, Professor Burr, and Mr. Morison. That estimate was gotten up by them and submitted to the full Commission for its action; and after going over it and talking about it we accepted those figures.

Senator MORGAN. So they just moved the figures up from the actual estimate as it summed up in figures to forty millions of dollars as an act of grace?

General HAINS. Well, I think, Senator, that if we had taken it that way we should have started with some higher figure than forty millions.

Senator MORGAN. I just wanted to know how they ever arrived at the round sum of forty millions of dollars when the calculations were less.

General HAINS. Well, you see by the figures there that they do not come out an even forty millions of dollars, but we just put down the lump sum.

Senator MORGAN. That is it?

General HAINS. We just took a lump sum.

Senator MORGAN. But in excess of the actual estimates that you had made, allowing 20 per cent for contingencies?

General HAINS. I really do not know, now, whether it is in excess or the other way.

Senator MORGAN. The figures show that it is.

General HAINS. It is not much either way.

Senator MORGAN. It is about a million of dollars—nearly a million.

Senator TALIAFERRO. General, were you a member of the Commission in 1902?

General HAINS. I was a member of the Commission, yes; on furlough without pay. The President, I might say, kept the entire Commission in existence for the purpose of calling it together in case anything should occur and he wanted to get the Commission together, you know, for any purpose; so that really the Commission of 1899 was not dissolved until March, 1903. But we had all been put on furlough without pay.

Senator TALIAFERRO. Do you know anything about the chairman of the Commission, Admiral Walker, at that time receiving such a telegram as this:

"The New Panama Canal Company declares that it is ready to accept for the whole, without exception, of its property and rights on the Isthmus the amount of \$40,000,000, the above offer holding good until March 4, 1903?"

General HAINS. I knew about that at the time; yes.

Senator TALIAFERRO. Would that not, in your judgment, absolutely cut off all demands on this Government for extra work or excess of work prior to that date?

General HAINS. I should think it would prior to that date, yes; but subsequent to that date was what I was referring to as what, it seemed to me, they might in equity have a just claim for.

Senator TALIAFERRO. Construing, now, that cablegram in the nature of an option, if that were extended beyond the 4th of March, 1903, by the French company, the period of extension would also be excluded in any demand for extra pay, would it not?

General HAINS. Yes, sir.

Senator TALIAFERRO. That is all I want to ask.

Senator ANKENY. In your estimate, what did you allow them, a yard, for this earth or material that went out of the Culebra cut?

General HAINS. Different prices.

Senator ANKENY. It was a fixed price per yard?

General HAINS. No, sir; there were several prices.

Senator ANKENY. But the basis of your calculation was so much a yard?

General HAINS. That was the basis of it.

Senator ANKENY. Then you allowed them, say, for 33,000,000 cubic yards, or some given sum?

General HAINS. Yes, sir.

Senator ANKENY. On the basis that you would use that much? That that was the basis of your whole offer, that that much was useful to this Government or to your Commission?

General HAINS. Yes, sir; to this Government.

Senator ANKENY. Now, suppose by some operation we use some more of their work; have they a claim for the difference in that?

General HAINS. No, sir; I do not understand so.

Senator ANKENY. In their bill you included so much, and you shut out the rest, because you did not need it, because you did not use it?

General HAINS. Yes, sir.

Senator ANKENY. If it was established that you did use it, do you think they would have any claim to it?

General HAINS. I do not think so. I am not a lawyer. I think you could tell that better than I.

Senator ANKENY. I am not a lawyer.

General HAINS. As a matter of law I do not think you could. As a matter of justice they might, under some circumstances.

Senator ANKENY. There is such a claim made, and that is the reason I speak of that. You remember, Senator Morgan, that there was a claim made, for instance, that allowed them for 33,000,000 cubic feet, or something, and that was all that was useful to us, and the rest was of no account. If we use more of that, what is our position in the matter?

Senator MORGAN. I was thinking of that in connection with the Gatun diversion. We throw that away, in the plan that is proposed by the minority of the committee.

General HAINS. You adopt a lock canal and you do not want it.

Senator MORGAN. We have paid for it and then throw it away.

Senator ANKENY. You do not understand that there is any claim against us for it?

General HAINS. No, sir; I do not understand that there would be any claim. I do not think they are making any.

Senator ANKENY. Not even in the Gatun matter?

General HAINS. No, sir.

The CHAIRMAN. General, I believe we are through with you, then, and we are very much obliged to you, sir.

(Thereupon the committee went into executive session; after which it adjourned until Thursday, March 29, 1906, at 10.30 o'clock a. m.).

WRITTEN STATEMENT OF GEN. HENRY L. ABBOTT,

U. S. ARMY,

**ON RELATIVE MERITS OF SEA-LEVEL
AND LOCK PROJECTS.**

ISTHMIAN CANAL.

The following communication is, by direction of the committee, printed as a part of the record:

2013 KALORAMA AVENUE NW.,
Washington, D. C., March 26, 1906.

HON. JOSEPH H. MILLARD,
*Chairman Committee on Interoceanic Canals,
United States Senate, Washington, D. C.*

SIR: In accordance with your request, I have the honor to submit the following views respecting the Panama Canal, now under consideration by your committee:

RELATIVE MERITS OF SEA-LEVEL AND LOCK PROJECTS.

The most important consideration from an engineering point of view in projecting a transit route, whether a railroad or a canal, is to adjust the details to the topography and natural conditions of the region to be traversed. On the Isthmus the Chagres River is the dominating feature. The canal and river must be near neighbors for about three-quarters of the entire distance, and the real problem is to so plan the former as to make it harmonize with the characteristics of the latter in the most perfect manner possible. The deep excavation in the Culebra section is a formidable undertaking, chiefly because it will be necessary to transport the spoil to long distances; but once executed, it will remain without giving occasion for anxiety in the future. The Chagres is capable of becoming a very active enemy at any future time unless effectively tamed by good engineering methods. It is not without interest to consider the character of this stream, which, under the influence of the tropical rainfall, differs radically from any in the United States.

During the three dry months of February, March, and April it is a small, peaceable river, about 200 or 300 feet wide, and carrying a volume of about 1,400 cubic feet per second at Bohio. The bed at Alhajuela, 58 miles from the sea by the course of the stream, is 92 feet above tide; at Gamboa these figures are 47 miles and 46 feet, and at Bohio 27 miles and zero feet. The rainfall in January and May is somewhat variable, and affects the flow accordingly. The other seven months are subject to tropical downpours aggregating about 12 or 13 inches monthly, and giving rise in the river to violent freshets, ranging in number, during the twenty-one years of which we have records, from none to thirteen per month. They often carry from 30,000 to 40,000 cubic feet per second, with oscillations of 20 to 30 feet, but they rarely continue more than twenty-four hours. The great floods are caused by long-continued storms, and fortunately are rare; only six have occurred since accurate records were inaugurated. The largest, that of 1879, had a rise of about 37 feet at Gamboa and 40 feet at Bohio, carrying,

respectively, 80,000 and 113,000 cubic feet per second. The most rapid rates of rise of which we have records occurred in the flood of 1890. They were 25 feet in seventeen hours at Gamboa and 19 feet in thirty-one hours at Bohio.

It remains to consider how so peculiar a river is dealt with in the sea-level and lock projects for the canal.

By the former an immense dam is projected at Gamboa by which the entire volumes of floods and freshets above that point are to be arrested and discharged gradually by sluices into the canal at a maximum rate of about 15,000 cubic feet per second, thence to flow to the sea in its channel. It is to be noted that this plan affords only a partial regulation, for long-continued and careful measurements demonstrate that in great floods only two-thirds of the volume that passes Bohio comes from above Gamboa, leaving still to be dealt with about 35,000 cubic feet per second delivered by the lower tributaries (enough to raise the Chagres 23 feet at Bohio). This it is proposed to do in part by forming two large permanent lakes on the west side of the Chagres, involving three dams, each rising about 75 feet above the ground and aggregating an estimated length of 4,110 feet, to say nothing of another dam 535 feet long and 25 feet above ground to close a low place in the bounding hills.

These two lakes are to be relieved of their surplus volume by cuts near the sources of the present streams, conducting the flow of the larger to the Trinidad River, by the channel of which it will return to join that of the latter and plague the canal levees near the Agua Clara marsh. But these dams regulate only three of the larger tributaries below Gamboa, leaving fifteen considerable streams and numerous drainage channels of the rainy season now discharging into the river to be led down into the sea-level canal from heights ranging between 20 and 40 feet above its surface. These water courses carry considerable sediment, and no adequate provisions for excluding it are contained in the estimates. The maximum current velocity thus generated in the canal is estimated by the majority at 2.64 miles per hour (about 4 feet per second).

The lock project is free from all these complications. By it the summit level, 85 feet above tide, extends from Gatun to Pedro Miguel in the form of a great lake which floods the valley to about 5 miles above Gamboa, and absorbs all the tributaries of the Chagres at such distances from the transit route as to effectively dispose of their currents and the sediment carried by their waters. The four regulating dams proposed by the sea-level plan are eliminated, being replaced by a dam and three locks at Gatun. Naturally these works have formed the point of attack by advocates of the sea-level plan, because the problem of how to regulate the Chagres is thus solved in a manner at once vastly better and vastly more simple than by their own. The startling criticisms raised against the lock sites have been shown to be groundless by cablegrams from Mr. Stevens just received. He has made a new personal examination, and pronounces the conditions as ideal for construction and permanency. The question of the dam, already discussed before your committee, will be briefly considered below.

It remains to compare the two plans for the canal in respect to the facilities which they offer for the transit of the Isthmus by the class of vessels contemplated by the law of Congress, namely, those "of the

largest tonnage and the greatest draft now in use, and such as may be reasonably anticipated."

The sea-level plan affords, for about 40 miles, a channel with a width at bottom only ranging between 150 and 200 feet, each of these widths covering about 20 miles, and having a uniform depth of 40 feet. Between Bohio and Miraflores, a distance of about 25 miles, the water surface of the canal is dominated by high banks which for about 8 miles rise considerably over a hundred feet, the maximum height exceeding 200 feet. Of the entire 49 miles between deep water in the oceans, 19 follow curves, gentle it is true, but not without difficulty for modern leviathans, especially at passings. Moreover, by being made the channel to carry the flow of the regulated Chagres such a route does not present the advantage of still water usually attributed to canals; in truth, it is a river, which is far inferior to quiet water for vessels whose length ranges from three to four times the available width between banks. The small depth of water under the keels of the larger class of shipping would greatly increase the difficulties of steering when the current, as at bends, acts unequally on the two sides.

The route for shipping afforded by the lock-canal project is next to be considered. From Gatun to Tavernilla, a distance of about 15 miles, and from near Miraflores to La Boca, a distance of about 4 miles, that is for a total distance of about 19 miles (one-third of the whole distance between oceans) ships will pass freely through a deep channel 1,000 feet or more wide and leaving nothing to be desired. The rest of the distance except about 5 miles at the Culebra Cut affords a channel ranging from three to five hundred feet in width, never less than 45 feet deep, and far superior in every point of view to that of the sea-level plan. This is true even at the Culebra Cut, for although the width is limited to the same figure (200 feet) the depth is made 45 feet, which will immensely facilitate the passage of great ships.

Except for about 4 miles north of Obispo there will never be objectionable currents in any part of the route, and even there they will disappear when the time comes to construct the Alhajuela dam to meet the lockage requirements of a distant future. Neither will sedimentary deposits trouble any part of the channel to be traversed by shipping. As to curvature, 30 of the 49 miles follow straight lines, and the great width of channel way will prevent any obstruction. The only drawback to these immense advantages is the necessity of passing the locks, and experience at the St. Marys Falls Canal sufficiently demonstrates how little this really ought to weigh in the comparison. It is safe to assert that if the decision as to which route is the superior could be left to a jury of practical navigators the result would not be doubtful.

It is well to recall that since the De Lesseps fiasco the question of sea-level or lock canal has been brought before three foreign and one American engineer commissions, aggregating 39 members, to whom should be added Mr. Choron, the eminent chief engineer of the French company. The decision without a single dissenting voice was in favor of a lock canal. This type alone furnishes a satisfactory solution to the problem of regulating the Chagres River, unless we are prepared to incur the expense of untold millions in opening a "strait" across the Isthmus.

In my judgement the primary consideration in choosing between the two projects should be their relative merits as routes for shipping. The elements of time and cost are secondary, but too important to be neglected. As a practical question, the estimates of both the majority and the minority were confined to engineering quantities and unit prices, but in a great public work covering so long a period it is well to consider unforeseen contingencies, such as failure of contractors, strikes among the laborers, possible epidemics, to say nothing of financial crises that may interfere with the annual appropriations of Congress, and even of a foreign war. In my opinion it is prudent to allow double the cost and double the time for the completion of the sea-level project, and, what is more important still, that when it is completed it will be distinctly inferior to a canal with locks. But to defer the completion to a period of say twenty years would be to tax the present generation for the cost of construction, and at the same time to deprive it of the enjoyment of any of the expected advantages. Such a proposition would hardly be agreeable to the tax payers.

THE DAM AT GATUN.

This question has been discussed at length before the committee, and only one further point suggests itself—the restricted area occupied by the material filling the two gorges in the indurated clay. This is insignificant in respect to the remaining impervious foundations of the dam, and if, what is highly improbable, future investigations should indicate that a moderate loss of water may occur it will be easy to control it by well-known engineering methods. The only really permeable material is restricted to the bottom of the western gorge, below the level of about 200 feet. The entire area of its cross section, only about 500 feet wide at top, is about 17,000 square feet; and it can readily be made impervious by pumping down cement. The entire area of cross section across both gorges being about 370,000 square feet, with a length at top of about 2,650 feet, the latter may readily be closed to a depth of 50 feet by modern sheet piling. These two simple operations would make absolutely impervious about 150,000 of the total 370,000 square feet, and by similar methods the whole area might be closed if deemed desirable. The entire question thus resolves itself into an engineering detail to be considered when the time comes to build the dam.

One advantage possessed by the Gatun site is worthy of attention. The whole region of the Chagres basin lying below Bohio is but little elevated above the sea; and this fact greatly reduces the height needed to raise the dam in order to submerge a wide area and thus obtain a large volume of water. The moderate height of 85 feet above tide suffices, while farther upstream the needful heights for reserving immensely smaller volumes are much greater. At Gamboa the height above ground is 130 feet, and even for the three dams on the west bank of the Chagres it is 75 feet. Nature thus simplifies the problem for the lock canal.

Another point may be mentioned. From lack of time no borings or surveys were possible at these latter three dam sites, and what they would have revealed is unknown. The estimates for them are scarcely better than an "engineering guess." Three months were too short a time for such studies.

OPEN GATES AT TIDAL LOCKS.

It has been urged before the committee that the tidal lock of the sea-level project is far less objectionable than an ordinary lock, because the gates may be left open for long periods when the tidal height does not differ materially from that in the canal. Actual experience at Kiel does not warrant this expectation. I visited Kiel shortly after the canal was opened, and was informed by the officers in charge that this expectation was entertained there. Locks had been deemed necessary because oscillations due to heavy gales reached extremes of plus 9.6 and minus 7.6 feet, or a total of 17.2 feet, but as ordinary tidal changes did not exceed a foot or two the gates would remain open most of the time.

I recently learned from Mr. Tincauzer, one of the members of our board, that such had not been the result of experience. The original intention of the canal authorities was to leave the gates open for three hundred and thirty days in the year, but they are forced to keep them closed almost all the time to avoid the moderate currents which have been found to be very dangerous for ships traversing the narrow space between the lock walls. This width is 82 feet, only 18 feet less than is projected for much larger ships at Panama. This fact proves that there is no material difference between tidal and other locks considered as obstructions to passage.

SIZE OF LOCKS.

The fact has been mentioned before the committee that the 1,000 by 100 foot size of lock was adopted by the full board by a vote of 11 to 2. As I happened to make the motion myself, you will pardon me if I give the reason. The discussion came up a little prematurely, because the lock committee were then engaged on the computations for determining the question of water supply of the canal in the dry season and had not reached conclusions. The drift of the discussion indicated plainly that the larger size would be adopted. This I considered larger than necessary, but I offered the motion in order to make it include the provision that intermediate gates should be inserted to reduce lockage volumes for small vessels. On my part it was simply a compromise, as I favored the smaller size.

LOCKAGE TIMES.

This question has been fully elaborated before the committee on theoretical grounds, amply justified by observations, but as I traversed the four upper locks of the Manchester Canal on one of the largest steamers that navigate it, specially to study this class of questions, the actual times noted may be interesting. The lift of the four locks was each about 16 feet, and the times noted at them hardly differed. The average indicated:

	Minutes.
To open gates	1½
To close gates	1½
To enter and tie	3
To loose and leave	3
Lift of 16 feet	7
Loss at lock	16

Add for loss in reducing speed when approaching the lock, and for regaining it again after leaving, nine minutes, making a total loss of twenty-five minutes for passing a lock. These figures tend to confirm the estimates of the minority as being ample and liberal.

ATTEMPTS TO INTERRUPT TRANSITS.

Fanciful speculations have been advanced tending to suggest dangers of this malicious character, but they seem to be wholly uncalled for. We stand pledged to open the route to the commerce of the world, and by adopting the policy of international agreement to its neutrality, so successful at Suez, all danger of the route becoming a battle ground will be eliminated. It is conceivable, however, that in the event of the passage of a fleet in time of war the hostile nation might plot its interruption, and as a military engineer, whose duties have made him familiar with the use of modern high explosives, I have given thought to the relative dangers of such attempts as directed against the two projects.

The most vulnerable points are not the locks and sluiceways, for these occupy but little space and would certainly be guarded effectively. The danger would be at the points where a narrow waterway traverses a jungle, favoring the placing of a bag of dynamite where the ship must certainly pass, and where a man concealed in the undergrowth could lie in wait to fire the mine with a portable electrical igniter, little exposed to danger of detection by a patrol. Such places abound on the long and narrow route of the sea-level project, but are rare and easily watched on the relatively broad lake route. The conclusion is thus manifest that the former has much more to fear from such operations than the latter. Moreover, actual experience at Suez has not developed any such hostile tendency.

DANGERS FROM EARTHQUAKES.

Fortunately the Panama route traverses a region less exposed to this danger than any other in Central America. It lies about midway between the long line of volcanoes extending southward from Colombia and northward from Costa Rica, and that destructive earthquake shocks are very rare is attested by the wide, flat arch in the ruins of the Santo Domingo Convent at Panama, which has stood uninjured since the early days of this ancient city. Accurate seismographic records kept recently for the same forty-four consecutive months at Panama and San Jose de Costa Rica indicate 4 slight shocks, lasting ten seconds, at the former, and 91 slight and 35 strong shocks, lasting sixteen minutes, at the latter.

A really formidable earthquake might disturb the adjustment of the lock gates, but could hardly affect such an artificial hill as forms the projected dam at Gatun. What it would do to an all-masonry dam rising 200 feet above its base at Gamboa, and sustaining, it may be, a head of 130 feet of water behind it, is not so certain. A failure of this dam from any cause would overwhelm a sea-level canal with a flood compared with which the disaster at Johnstown would be as nothing.

LOW-WATER SUPPLY OF THE CANAL.

Doubts have been suggested to the committee as to the sufficiency of the water supply of the lock canal when the traffic becomes very great, and a few facts as to the matter may be not without value.

The area of the basin of the Chagres above Bohio is about 700 square miles and above Gatun about 1,200 square miles. The area of lake surface above Bohio is 38.5 square miles and above Gatun approximately 110 square miles, or practically three times greater.

The long and careful series of water measurements conducted at Bohio for fifteen years have made certainly known what volume of water the river will contribute during the three months when the natural flow falls below the requirements of the canal. The absolute minimum volume in this long period was 742 cubic feet per second at Bohio and about 1,225 at Gatun. Allowing 4 feet in depth over the entire lake surface as a reserve, we have an additional volume of 1,577 cubic feet per second available, making a total of 2,802 cubic feet per second to draw upon. Part of this must be allowed for unavoidable losses, for which my estimate is the following, based on the most careful study of all existing data:

	Cubic feet per second.
Evaporation	710
Leakage at gates	250
Infiltration	77
Lights, power, etc	200
Contingencies	200
Total	1,437

Claims that there may be leakages through the two gorges in the indurated clay at the Gatun dam have been made before the committee, and it has even been imagined that percolation under this indurated clay is possible, such losses suggesting danger to the low-water reserves. The answer is simple. Since losses due to evaporation and leakage at gates are well understood, and the allowance for lights, power, etc., is ample, the above figures would cover a loss by infiltration equal to half the low-water flow at Bohio before calling for larger reserves. Furthermore, as will appear below, the only effect of such purely hypothetical and exaggerated losses would be to hasten the construction of the Alajuela dam, and thus to secure an unlimited supply.

Resuming, after this digression, the consideration of the low-water-supply problem, we find for the water available for lockage the difference between 2,802 and 1,437, that is to say, 1,365 cubic feet per second. The size and lifts of the locks being known, the calculation of the lockage prisms for one transit of the canal is readily made. It demands a continuous flow of 52 cubic feet per second. Having 1,365 cubic feet available, it is clear that 26 daily transits are provided for, which would accommodate an annual traffic of some 28,000,000 or 38,000,000 tons, depending on the average size of the vessels. When this limit is approaching it will be needful to provide a dam on the upper Chagres for additional reserves. An ideal location exists at Alajuela, some 10 miles above Gamboa, which is vastly preferable to the latter as a dam site.

A design for a dam at this place was carefully elaborated by the engineers of the French company, for which the estimated cost was

\$2,400,000. With a water surface rising 130 feet above the bed of the river this masonry dam will afford a reserve yielding a flow of 2,074 cubic feet per second for ninety days, which is sufficient to support 40 daily lockages. Only 27 were assumed in the computations of the minority, giving, with the 26 above explained, 53 in all, which would correspond to an annual traffic of about 80,000,000 tons. Obviously this is a very conservative estimate of what the Chagres may be counted upon to supply. It is absolutely certain that there can be no deficiency of water for any conceivable traffic demands.

In conclusion, I beg you to pardon me if I venture to suggest that as three months was a short time in which to study details in a problem involving so many variants as that of the best possible lock canal, a problem for which the New Panama Canal Company gave its engineers three years and nine months before rendering its report, it would be in my judgment wise to leave considerable latitude to the Commission in preparing the final working drawings, if this type be preferred by your committee. Too narrow limits in wording might tend to defeat the intention of the legislation.

Very respectfully,

HENRY L. ABBOT.

STATEMENT OF GEN. GEO. W. DAVIS,
U. S. ARMY,
BEFORE THE COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE.

ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Thursday, March 29, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Ankeny, Morgan, Taliaferro, and Simmons.

STATEMENT OF MAJ. GEN. GEORGE W. DAVIS, U. S. ARMY, RETIRED.

Senator KITTREDGE. You may state your name, General Davis.

General DAVIS. George W. Davis.

Senator KITTREDGE. And what is your age?

General DAVIS. I am 67.

Senator KITTREDGE. And your residence?

General DAVIS. At present in this city; I have no fixed residence.

Senator KITTREDGE. What has been your profession or business?

General DAVIS. I have been in the Army since 1861, with a very brief interval.

Senator KITTREDGE. And connected with the Engineering Corps during that time?

General DAVIS. Connected with engineering works a part of that time; I have not been connected with the Engineering Corps as a corps, but with engineering works. I have been on duty under engineer officers, officers of the Corps of Engineers.

Senator KITTREDGE. You were a member of the Isthmian Canal Commission, which was appointed in March, 1904?

General DAVIS. I was.

Senator KITTREDGE. When did you go to the Isthmus?

General DAVIS. On my first trip to the Isthmus I sailed from New York on, I think, the 2d, 3rd, or 4th of April, 1904.

Senator KITTREDGE. In what capacity did you serve on the Isthmus, and how long did you remain there?

General DAVIS. I only remained there on that occasion about two weeks. The whole new Isthmian Canal Commission visited the Isthmus at that time and spent about two weeks there for general survey and observation and then returned to the United States. We arrived back at the end of April. At the beginning of May an Executive order was published containing instructions for the guidance of the Isthmian Canal Commission, and on the following day, the 10th of May, I again left for the Isthmus under orders of the President appointing me governor of the Canal Zone and directing me to take general charge of the work then in progress on the Isthmus. I

arrived there on the 17th of May and left there on the 10th of May of the following year. I was there a year, less a week.

Senator KITTREDGE. In addition to your duties as governor of the Zone, what were your duties otherwise as a member of the Commission?

General DAVIS. I was ordered by the President in this Executive order to take charge of the peace and good order on the Isthmus as governor of the Zone. I was ordered by the Isthmian Canal Commission, of which I was a member, to take charge of the work then in progress and to conduct that work until the arrival of the chief engineer, which was to occur presumably in a few weeks. I carried out those instructions, and on the 1st of July the chief engineer, Mr. Wallace, took over the engineering work and continued in charge of the engineering work thereafter, reporting through me to the Commission until the Commission arrived there in August and changed the channel of report, directing, then, that he report to the Commission and not through me as an intermediary or as a channel.

Senator KITTREDGE. Were you a member of the engineering committee of the Isthmian Canal Commission to which you have referred?

General DAVIS. Some time in the winter or autumn of 1904 the Isthmian Canal Commission divided up its members into committees. I think there were five in all, and I was made a member of any committee that might be visiting the Isthmus during such period. I was made ex officio a member of any committee that might be there. The only committee that ever came there as a committee to transact business was the engineering committee, consisting of Mr. Parsons and Mr. Burr. I became a member of that committee by virtue of the fact that they met on the Isthmus, and as such sat with them and deliberated.

Senator KITTREDGE. Where did you live while on the Isthmus?

General DAVIS. I lived for two months after I arrived there on the top of the Culebra Hill, in one of the vacant buildings that the French had turned over to us, just alongside of the Culebra excavation. After I had succeeded in getting an old building fixed up that the superintendent of wagons or teams or teamsters had used under the French régime, when I had had it made habitable, I moved into that building, on the outskirts of the city of Panama, which was more convenient for my purposes.

Senator KITTREDGE. I suppose you were frequently over the route of the canal?

General DAVIS. Oh, many, many, many times.

Senator KITTREDGE. And you kept in touch with what was going on?

General DAVIS. I tried to. I think I was intimately acquainted with it.

Senator KITTREDGE. The engineering situation as well as governmental features?

General DAVIS. I had very close and very intimate relations with the chief engineer, Mr. Wallace. I became quite well acquainted with him, and he was quite cordial with me, and there appeared to be no matters going on between us of which each was not thoroughly aware. He told me of his plans, of his methods, of his processes; and in like manner I talked with him about my business. While there was no

necessity for our doing that, yet it was felt to be wise to be in perfect harmony.

Senator KITTREDGE. You were a member of the Board of Consulting Engineers?

General DAVIS. Yes, sir.

Senator KITTREDGE. And signed the majority report?

General DAVIS. Yes, sir.

Senator KITTREDGE. In favor of a sea-level canal?

General DAVIS. Yes, sir.

Senator KITTREDGE. Are you familiar with the report of the minority of the Consulting Engineers?

General DAVIS. I am; yes, sir.

Senator KITTREDGE. Also the report of the Isthmian Canal Commission—the present Commission?

General DAVIS. I am; yes, sir.

Senator KITTREDGE. Have you read the testimony of the witnesses?

General DAVIS. I have; all except that of General Hains.

Senator MORGAN. I would like to ask you whether at the close of the Spanish war you were made governor of Porto Rico?

General DAVIS. Yes, sir.

Senator MORGAN. How long did you serve in that capacity?

General DAVIS. I arrived there in May, 1899, and turned over the government of the island to the civil governor on the 1st of May, 1900. I remained in Porto Rico until the following December, in command of the forces there, and with instructions to cooperate with the new governor and assist him in every way I could to get the civil government of Porto Rico started off.

Senator MORGAN. While there you had the task of organizing the civil government in Porto Rico under the Government of the United States?

General DAVIS. I did, sir, in way of preparation and assistance.

Senator MORGAN. And virtually did the whole work?

General DAVIS. Well, I should scarcely want to claim credit for everything. I carried out the instructions of my superior, the Secretary of War, Mr. Root—I tried to.

Senator MORGAN. Did you, at any time during or after the Spanish war, have any power of government or command or control in the island of Cuba?

General DAVIS. Before that I had; yes, sir.

Senator MORGAN. Before you went to Porto Rico?

General DAVIS. Yes, sir. I went to Cuba in the autumn of 1898, and landed the first regiment that landed in Habana, and then went and organized the military government of the province of Pinar del Rio, the western end of the island of Cuba, and remained there until the following February.

Senator MORGAN. You were in charge of the military government at Pinar del Rio?

General DAVIS. Yes, sir.

Senator MORGAN. You were not in charge of the Santiago government at any time?

General DAVIS. No; I never was in Santiago.

Senator MORGAN. Then afterwards you served in the Philippines?

General DAVIS. I left Porto Rico in December, 1899, and in January I was in the Philippines.

Senator MORGAN. What were your duties and official functions out in the Philippines?

General DAVIS. I was appointed inspector-general of the troops in the Philippines upon my arrival, but only remained in that position about two or three weeks. I was then detailed by the commanding general in the Philippines as provost-marshal-general of the Philippine division, and was assigned to duty in command of the troops stationed in the city of Manila, which made me practically the military governor of the city of Manila, with instructions to organize that government and get it ready for a civil government as soon as possible. I did so, and six months later I turned over the government of the city of Manila to the commissioners who had been designated by the Philippine Commission to govern the city; and I then went to the southern Philippines in command of one of the departments, and carried on some military operations in the southern Philippines.

Senator MORGAN. What civil functions did you perform during the remainder of your stay there?

General DAVIS. After about a year's stay in the southern Philippines, holding the position, practically, of military and civil governor (if the two functions can be considered to be merged, because the Philippine government had not at that time assumed civil government in southern Mindanao and the Jolo Archipelago), I went back to Manila in July or August, 1902, and commanded the military forces in the island of Luzon for about two months, and then relieved General Chaffee as commander of all the forces in the Philippine Islands. That was on the 1st of October, 1902, and in the following July, ten months later, I was retired from active service and came home.

Senator MORGAN. Did you come home under any new appointment?

General DAVIS. No. I had been informed that I was likely to be appointed a member of the Inter-oceanic Canal Commission. I had received an intimation to that effect.

Senator MORGAN. How long was it after you returned before you were appointed?

General DAVIS. I came home through the Suez route and arrived in November, and in the following March I was appointed.

Senator MORGAN. Having had an intimation of your appointment as one of the Commission, when you passed through the Suez route did you give particular attention to that route?

General DAVIS. It was the principal reason why I came home that way, so that I could see it and study it.

Senator MORGAN. You wanted to study it before you took your office as Commissioner?

General DAVIS. Yes.

Senator MORGAN. That is all I wanted to ask the General.

Senator DRYDEN. Did you spend any time at Suez besides passing through the Suez Canal as a traveler?

General DAVIS. No; I was only there two and a half days, I suppose, in all. I should have liked to spend a week or two there, but the movements of the transport did not permit.

The CHAIRMAN. General, will you now proceed (if there are no other questions to ask at this point) and give the committee such information as you have prepared for it?

General DAVIS. Gentlemen, I have prepared some notes here which represent some ideas that I will express to you, with your permission, and will make them the basis of any subsequent remarks or answers to interrogations which you may wish to put to me. If you wish to interrupt me at any time, do not hesitate to do so, because I can take up the thread of my remarks easily.

The CHAIRMAN. The committee will endeavor to let you go along and finish your statement as far as possible, after which we will probably want to ask you a number of questions.

General DAVIS. What I have to say begins with certain general considerations that relate to the canal question in a very large way and have nothing to do with the type or physical features.

There are some general phases of the isthmian canal question that do not seem to have received attention in the consideration of this committee, so far as may be judged from the printed reports of the hearings. I would like to be permitted to briefly discuss a phase of the question affecting type ultimately that has no concern at the moment with the subject of locks, sea levels, dams, curves, prisms, speed, capacity, and safety.

The aspect of the question that it seems to me has so far been overlooked requires for its elucidation a consideration of the geography of the earth and the size, situation, and relation of the continents and oceans to each other, together with the distribution of the world's population.

A glance at a map of the Eastern Hemisphere shows graphically certain facts respecting the physical conditions and relations of the densely and sparsely populated areas to what are and must always be the great commercial activities of trade, commerce, and travel.

In Europe and Asia are found nearly two-fifths of the habitable land areas of the globe, and within them live more than four-fifths of the world's inhabitants. Africa contains nearly one-fourth of the globe's land area and contains about one-twelfth of its inhabitants.

The Arctic Ocean, lying in the north of Europe and Asia, does not supply a practicable marine route between the eastern and the western seas. The Atlantic, Pacific, and Indian oceans, with the Mediterranean and Red seas, border Europe and Asia on the west, south, and east; and the natural obstacle—104 miles wide—that was interposed to the mariner at the Isthmus of Suez, was removed by man many years since, so that now the ocean-borne coasting trade of this vast northern area and population encounters no obstacles to free movement save those that the winds and waves interpose everywhere on the ocean to the sailor. The population of the northern and northeastern shores of Africa also depends upon the Suez route in passing between the Atlantic and Mediterranean waters on the one side and those of the Red Sea and Indian Ocean on the other.

All the inhabitants of Europe and Asia and half of those of Africa that are in any way interested in water-borne interoceanic commerce of the eastern world are served by the Suez Canal, that joins the Atlantic and Mediterranean to the Indian and Pacific waters; or their vessels must double the Cape of Good Hope, which involves an increased distance of 2,700 miles as a minimum and 4,300 as a maximum.

In the Western Hemisphere the geographical conditions are not dissimilar to those just referred to, although the areas are much

smaller, and the populations now waiting for better and shorter means of interoceanic transit are very many times smaller.

There is in the western as in the eastern world no navigable waterway through the Arctic, and no way for a vessel to pass directly between the Atlantic and the Pacific save by doubling the southern extremity of South America. But the obstacle that nature has interposed to a shorter route of travel and trade is fortunately not an insuperable one; for a canal half as long as that at Suez through the Isthmus of Panama will shorten voyages between North Atlantic and North Pacific American ports, via Cape Horn, by a distance of 9,600 miles, or considerably more than double the saving that the Suez Canal permits between England and India. Subjecting Panama to the same treatment that resulted in joining the Mediterranean and Red seas will result in separating the American continents and joining the oceans, just as the making of the Suez Canal did in the Old World.

The density of the population to the square mile in Europe is 107 and in Asia 57. When North and South America shall have been peopled as densely as is Asia now, the total American population will reach 760,000,000 souls.

When we consider that there is more waste land in Asia than in the two Americas; that the Indian population of nearly 300,000,000 is distributed at the rate of 164 to the mile; that the 28,000,000 inhabitants of Java, a little larger than Cuba, have a density of 568 to the square mile; that migration from the Old to the New World is proceeding at an enormous rate, and that it is an ever-increasing one, we may well believe that the New World may in one or two centuries have a thousand million inhabitants, and that it may attain to one-third of this figure by the time the Panama Canal shall have been in commission fifty years.

It seems to me, then, that we should have these considerations constantly in mind when discussing the capacity, dimensions, and type of this great waterway, that can never have a rival save the other continental interoceanic canal at Suez. Should it not be at least as capacious, free, and unobstructed as the best of the excavated channels that man has made, or that he will ever be called upon to make?

What the situation demands is well known, and the American Government has declared to the world that the obstacle at Panama shall be removed. Will it be removed if we leave a hill over which the world's commerce and navies are to be hoisted? Will the world consider that we have adequately solved the problem, and will the American people be satisfied with the result if we offer them anything inferior as respects capacity, or convenience, or adaptability for enlargement, or type, to what private capital did for the Old World—a canal which now serves as a model, and will continue to until we acquit ourselves of the responsibility voluntarily and eagerly assumed?

Two object lessons: There is in the United States no really maritime canal; and, fortunately, the physical characteristics of the land do not require that any be made. Cape Cod may be segregated from the rest of Massachusetts; the Delaware and Chesapeake bays may be joined, and the Florida Peninsula may be traversed by a waterway; but these are all subsidiary—merely possible conveniences. But the Panama Canal is not in this category.

Only one of our many internal waterways has ever been considerably enlarged and adapted to use by vessels of considerable size. I refer to the one between Lakes Superior and Huron, which really is not a canal at all, but instead a lock proposition with a few thousand feet of channel approaches and jetties at each end. Its locks are more analogous to some of those great tidal harbor basins of Europe, to which access for the loading and discharging of vessels is afforded by locks or gates, than to an interoceanic canal.

The Soo Canal, so called, is a mile and six-tenths long. The six locks in the minority's plan of the Panama Canal are $2\frac{1}{2}$ miles long. These locks alone of the proposed lock plan at Panama are nearly a mile longer than the whole Soo Canal with its lock.

Had Nature given to Lakes Superior and Huron a common level, as she has to the oceans, the supposed obstacle at the Soo to free communication would have long since been removed by the construction of a channel clear of all obstructions, and this regardless of any cost that was within our capacity and resources. But, unfortunately, Nature made such simple treatment impossible, for Lake Huron is twenty-odd feet lower than Lake Superior. It was useless to wish for an ideal treatment of the obstacle, for it was an impossibility; and American and Canadian engineers have provided the best solution possible.

At first locks 350 feet long sufficed. Then one 515 feet long was added. Next the first were demolished and replaced with a lock with chamber 800 feet long. Then the Canadians made another in their territory 900 feet long; and we are about to demolish our second lock to put in one 1,400 feet long. So now there are three parallel locks at the Soo, with a combined length of 2,215 feet, soon to be increased, not in number, but in length, to 3,100 feet.

Senator KITTREDGE. May I interrupt you there? I did not quite understand the statement regarding the 1,400-foot lock.

General DAVIS. Congress, as I understand, has authorized the construction of a 1,400-foot lock at the Soo, and they propose to tear out the Weitzel lock and put the new 1,400-foot lock in its place. I am told that by the engineer in charge.

Senator KITTREDGE. Does that mean a lock with usable dimensions of 1,400 feet?

General DAVIS. With usable dimensions of 1,400 feet, less the swing of the gates; yes.

Senator DRYDEN. Is the object of lengthening that lock to permit more of the medium-length vessels to get in at one time?

General DAVIS. That is it; that is it. They put in two, three, four, five, six of those boats and barges, you know. The whaleback barge is a common method of transportation there.

Senator MORGAN. In what act was provision made for that 1,400-foot lock?

General DAVIS. I could not tell you offhand, Senator. My information comes from the engineer who is in charge of the Soo locks. He says that they are just now making their plans to tear out the Weitzel lock and put in a 1,400-foot lock.

Senator MORGAN. It is one of those things that slipped into an appropriation bill, I suppose.

General DAVIS. I can hunt it up.

Senator MORGAN. We will get it. I was just inquiring.

General DAVIS. My information is based on what Mr. Ripley said.

Senator TALIAFERRO. The point in that, General Davis, is that it has been found necessary to enlarge these locks from time to time?

General DAVIS. Continually. I am coming to something else upon this point which is quite pertinent to it.

If the commerce of the Great Lakes continues to increase in the future as in the past, this plant for making the transit at the Soo will be overtaxed, and more locks or larger ones demanded. On the other hand, an international commission is now in session considering the question of a probable, indeed certain, inadequate water supply for the combined purposes of navigation and other industrial uses; for it is evident that the one or the other must be curtailed. General Ernst is a member of that commission, and they are now trying to draw up regulations to get the two countries to agree to specify that this industrial establishment shall not use more than so many second feet, or that that one and all shall not use more than so many second feet, or that the whole use of water on the American side shall not exceed so much, and so much on the Canadian side, so that there will be left enough to serve all purposes partially.

Senator MORGAN. All purposes of navigation?

General DAVIS. Yes; and industrial purposes, too. Navigation is an industry. I do not know that the navigation men have any superior claim with respect to the use of waters over those who may have riparian rights along the channel. However, that is aside from my purpose.

The Soo locks have served a most beneficent purpose. They have been admirably managed. They are an object lesson that the Board of Engineers very carefully studied. But when we endeavor to apply at Panama the principles governing at the Soo, and propose to equip the interoceanic canal with devices such as could not be dispensed with at the old lake portage, the lesson of the Soo is inapplicable. A lock or locks of small lift was necessary to overcome the difference of level; but at Panama there is no difference of level that can not be surmounted in the same way that the Suez interior elevations were.

The ships plying the Lakes are built to suit the lock conditions, and they pass and repass every ten days or two weeks during the open season. During the closed season—one-third or more of the year—the boats and the locks are idle, and there is a time for general overhauling; for it is certain that no vessel will ask passage either up or down. But at Panama the ships will not be specially built for the canal, but for the navigation of the broad oceans, and there will be no time, either months or days, when the canal will be out of use.

It has been claimed that since it is proposed to make the Panama locks in pairs there will be ample time for the overhauling of one flight by putting it out of commission temporarily and depending solely on the other flight. But when the traffic increases so as to approach or reach the limit of capacity of both flights, the disuse of one for even a few days would cause intolerable delays; for one will never know when an accident disabling a lock will occur.

This example of the successful use of locks at the Soo has apparently served as an object lesson to many American engineers who are forgetful or ignorant of the splendid examples of Suez, Kiel, and Corinth. It sometimes seems that in some men's minds it may have come about that the canal at Panama, or indeed any canal, can not be

thought of even save in terms of locks, for if all the arguments that have been adduced in praise of these devices be accepted as sound, then it would seem to follow that the only way to make the Suez Canal perfect would be to put a lock at each end and feed the summit level from the Nile, a proposition that was once seriously considered in a way at a time when it was alleged that the Suez Canal, as it was in 1870 to 1880, would soon be inadequate.

It has been suggested that the adherence of the majority of the Consulting Board, including all the foreign members, to this sea-level idea, may have been due in part to the fact that the great canal of the Old World is that at Suez, while the great canal of the New World is the Soo—one at a uniform level and the other in two levels; also that the recommendations of the majority are vitiated by their having ignored the latter.

I hope to be able to show you, gentlemen, that there are very good, indeed abundant, reasons for the expressed preference of the majority to make the Panama Canal conform in type to the former.

At least three of the majority, including one foreign member, have seen the Soo lock in operation; but I am told that not one member of the minority or of the Commission ever saw the Suez Canal, while several of the majority, including one American member, have personally inspected that greatest of all maritime canals. If there is an inadequacy of personal knowledge by the members respecting either object lesson, it would seem to apply with most force to the minority as respects Suez.

There has been a reference made in the papers before you to what is claimed to be a fact, that the tonnage passing the Soo locks is three times greater than that passing Suez. In 1905 the Suez Canal passed 13,000,000 net tons, and there passed the Soo some 36,000,000, or about two and three-fourths times as much tonnage. A valuation of this freight at \$10.60 per ton, the figure of 1904 (I have not the value for 1905), would give the aggregate of the commodities transported at the Soo a value of \$381,000,000. The goods handled consisted largely of articles of the least unit value of any transported anywhere, such as iron ore and coal, representing over 27,000,000 tons in 1904 out of a total of 31,500,000.

What is the value per ton of the freight passing through the Suez Canal? We have no means of knowing; but it must be many times greater than the raw materials moved between Lakes Huron and Superior. A large part of it must be general merchandise, which at the Soo is placed at \$135 per ton. It would seem to be conservative to estimate the Suez freight at \$50 per ton, in which case the value of that traffic would reach \$650,000,000, or nearly double the value of Soo freight. If it be put at \$30 per ton, the figure would be \$390,000,000, or quite equal to the other. So that we see that the actual importance of the two routes measured by the value of the goods moved is probably greatly in favor of the Old World canal.

Again, if the value of the ships using both routes be taken into account, the comparison would be still more in favor of Suez; for there are moving in constant procession many of the most costly ships in the world—great commercial liners, battle ships, and cruisers—while the ships plying on the Great Lakes are generally the simplest freighters and barges.

As a route of travel, the contrast is still more remarkable. The number of passengers passing the Soo in 1904 was 16,120, while the number passing Suez in 1902 (the last year for which the data are available) was 223,775.

The statement that the Soo transit is three times as important as that at Suez seems to have no sufficient basis of fact to support it. Why, then, should not the Board of Engineers, with all the data available, physical and statistical, have assigned more importance to the traffic figures of the Old World example than to those pertaining to the other? And why should not those gentlemen, chosen to advise upon a solution of the Panama problem as respects type, have endeavored to present a feasible plan for adoption that would insure the realization of a waterway better in every respect than the best that exists, so it be realizable at an expenditure in money within the financial capacity of this great nation and within a reasonable period of time?

If any of those who have formed and expressed opinions upon this question of type are beset with an idea that has controlled or warped their judgment by what has been sometimes called a mental obsession, to which group do they belong?

Now, as to the type—whether sea level or with locks:

I have, I think, read about all that has recently been printed by the Government in the way of criticism or commendation of the majority and minority plans for a canal at Panama. What I propose to say as respects this important question will be said as a layman to a lay audience. The President and the Secretary of War have submitted their opinions, and we have also been favored with an expression of judgment by the Isthmian Canal Commission and its present and former chief engineers.

The critics of the majority report admit that a canal at sea level would have certain advantages. I think it may be said that one and all concede that if a sea-level waterway be wide and deep enough it would be superior to any involving excavations, lakes, locks, and lifts; but they discard it as impracticable because of the greater cost.

Some or all those who favor a plan involving 170 feet of lockage admit that the Suez type would be somewhat less exposed to damage in time of war; that the operating and maintenance expenses alone would be less, and that small ships would traverse it quicker than the others. On the other hand, it is claimed that the majority estimate of cost is too low; that there would be very much more liability to accident during construction; that it would require about twice as long to construct; that its transit by large ships would be less speedy; that it would be more difficult to enlarge—in short, that the canal made as proposed by the minority would be safer, more feasible and desirable than the other.

The propriety of a discussion by an officer of the Government of the officially expressed opinions of his superiors should not be permitted or thought of. This is an elementary proposition that no one will question. As I had been informed that I was to be called before this committee and questioned respecting my views upon the subjects that had been receiving attention here, I took occasion to ask the Secretary of War how far he wished me to go in discussing the subject, upon which he had submitted a recommendation to the President.

He asked me to say to this committee that he desired that I feel myself entirely free to elucidate to you in the fullest manner the questions you are considering.

The letter to the Secretary of War transmitting the reports of the Board of Engineers and the review of the same by the Isthmian Canal Commission and its chief engineer are before you. Certain conclusions have been reached by the Secretary from a study of the papers transmitted that seem to me to be based upon misconceptions of fact or a misunderstanding of the arguments and conclusions which are the subject of his review. With your permission, therefore, I will briefly invite attention to some of the more important of his observations and endeavor to show that too much or too little weight has been given to the sea-level and lock-plan arguments.

As to the question of a winding waterway and tortuous navigation—those being some words that the Secretary has used in his letter as applied to the sea-level plan:

The total curvature of some existing and proposed canals, expressed in degrees of arc, is as follows: What I mean by that is, that when you turn a certain curve, you also make a change of direction measured by a certain number of degrees. Each curve has its own angular measurements. Adding together all those angular measurements gives the total angular measurements for the canal route. That will explain what I am going to say.

The proposed Panama sea-level canal has 597° of curvature, as proposed by the majority. The proposed Panama lock canal has 637° of curvature, as proposed by the minority. The existing Kiel sea-level canal—that is, the state canal of Germany, which connects the North Sea and the Baltic, and which has been built primarily for the purpose of enabling the German fleet of war vessels to pass and repass without going through the Danish channels—has 830° of curvature in a distance of about 60 miles. I have the exact distance here somewhere. The existing Suez Canal has 530° of curvature—the present one.

Senator TALIAFERRO. In what distance?

General DAVIS. In 104 statute miles.

The minority claim that all sailing courses in their lock plan are straight lines, and that moving vessels will simply change direction at points where these straight lines meet. But curves are shown on the lock plan at each change of direction. A vessel changing direction in these curves will not come to a full stop in the angle and take up the new direction as from a fixed point. If she did that, she would have to be pulled and pushed about with tugs; she would have to turn as on a pivot. They do not propose anything of that kind; but she will sail around the curve, and if her course is as plotted on the lock-plan map, she must sail these curves and make the angular changes, 24 in number. I think General Ernst yesterday counted them up and only noticed 18. There are 24 on their schedule of curves, which I have before me, compiled by the minority.

Senator MORGAN. On the lock canal?

General DAVIS. On the lock canal; 24 of these changes of direction, as against 19 in the sea-level plan, or 21 per cent more winding and tortuous navigation for the lock than for the sea-level sailing courses.

This defect of the lock plan is claimed to be cured and more than cured by making the channels broader. But there is a difference of opinion as to this. I quote from Admiral Goodrich, of our Navy, Admiral Ryder, of the British navy, and Sir John Stokes, of the royal engineers, who was the senior for about twenty years of the British members of the board of directors of the Suez Canal, in which, as you know, England owns nearly one-half the stock, and is therefore represented in the board by her own appointees.

The present Admiral Goodrich (now stationed, I think, in California, commanding the North Pacific Station) passed through the Suez Canal a good many years ago; and in his report to the Secretary of the Navy this is what he says about the navigation. I will ask you to remember that at that time the Suez Canal had a bottom width of 72 feet and a depth of 26 feet. [Reading:]

"Two causes of bad steering are to be apprehended, one the effect of the ebb current in the southern section, which begins to be felt 12 miles from Suez and reaches 3 miles an hour at the terminus. Another imminent source of grounding is due to unequal width of the deep-water section, which is particularly noticeable at the sidings. So long as the channel is of uniform width a vessel steers steadily and without the use of the rudder. If the course be straight, vessel will follow the mid-channel, for the reason that the reflex pressure from the banks is equal on both sides."

Senator TALIAFERRO. General Davis, what does he mean by the vessel steering "without the use of the rudder?"

General DAVIS. Just what he says—that when that vessel is started off on a straight course in the canal you can let the rudder alone and the vessel will take care of herself. That is a fact.

Senator TALIAFERRO. Is it?

General DAVIS. Yes, sir.

Senator TALIAFERRO. It is news to me.

General DAVIS. I do not mean to say that they do not keep their hands on the rudder; but he says here that they will steer without the use of the rudder.

Senator DRYDEN. Does that refer to a vessel propelled by steam?

General DAVIS. Oh, yes; oh, yes.

Senator MORGAN. Does that mean that the vessel is really steered by the propeller?

General DAVIS. No, sir; it means that the pressure of water on both sides is exactly equal, and there is no prompting on the part of the vessel to go to one side or the other, for the place of least resistance is right in the center of the canal.

Senator MORGAN. They go for the point of least resistance?

General DAVIS. They go for the point of least resistance, and if they should go toward the bank they would meet with resistance. If they should go toward either bank they would meet with resistance, so the place where the vessel can go ahead easiest is reached in the center of the canal, and that is what Admiral Goodrich says. [Reading:]

"So long as the channel is of uniform width a vessel steers steadily and without the use of the rudder; if the course be straight, vessel will follow the midchannel, for the reason that the reflex pressure from the banks is equal on both sides; but where the width is increased by an enlargement wholly on one side the pressure varies,

being, if the width is doubled, four times as great on the side of least extent of deep water as on the other."

That is, these pressures are as the squares of the distance.

"In consequence the ship yields to the greater pressure and heads directly for the transverse bank which makes the end of the siding."

He is talking now about these sidings in the Suez Canal, which were made in order to facilitate ships passing each other. They are mere notches, cut right out of one side or other of the bank, and of course the end of the notch represents a transverse wall of earth. He says that a ship coming abreast of one of these enlargements shunts right off for the enlargement—that is, she tries to get to the center of the channel all the time.

Senator MORGAN. Ships that are put into these notches are stopped?

General DAVIS. They are stopped absolutely, and tied up there until the other one goes by.

Senator MORGAN. Until the other one goes by; yes.

General DAVIS. On the subject of increasing the width of canal, which from about 1870 to 1880 was under discussion, Admiral Ryder, of the British navy, reported:

"At first sight it might appear advisable that the canal should be widened, but I am convinced it would be a misfortune, as wild vessels that now cannon harmlessly from bank to bank of the ditch, which is only 72 feet across, would then, instead of cannoning, dig their stems in and stick perhaps for hours."

Senator TALIAFERRO. General, before you proceed, do you know the width of the Suez Canal at these points for passing—for ships to pass each other?

General DAVIS. At that time they were much less than the figure I give you now, but now they are 147.6 feet. That is their width now.

Senator TALIAFERRO. At the passing places?

General DAVIS. At the passing places; yes, sir.

Senator KITTREDGE. At the bottom or the surface?

General DAVIS. At the bottom.

Sir John Stokes, of the Royal Engineers, in his report to the Government—this is an official paper—says:

"It has been urged as a reproach against the company that it did not excavate a channel of the full width originally intended, namely, 200 feet at the surface and 144 feet at the bottom."

That was the plan that Mr. De Lesseps set out to accomplish. He got just half of that—that is, he got 72 feet instead of 144. [Reading:]

"But I think it is a fortunate circumstance that the intention was not carried out. I believe that the navigation is, in consequence, effected in much greater security, that the risk of collision is greatly reduced, and that in the long run the passage through the canal is performed in a much shorter average time than if vessels were allowed to navigate without supervision. If the canal were wider, and vessels allowed to navigate without restriction, obeying only the rule of the sea, the usual rivalry and endeavor to get through as quick as possible would, even if restrained by regulations, be accompanied by the usual collisions sometimes occurring from accidents beyond control.

"There is practically no limit to the number of vessels that can be passed; the present 'sidings' can be increased in number, but as

the large Bitter Lake affords the means of shunting any number of vessels."

(At this point General Davis indicated on the map the location of the Bitter Lake on the Suez Canal.)

Senator KITTREDGE. How far is that, General, from either end?

General DAVIS. That is about 25 miles from the Red Sea, and this end of it is about 60 miles from Port Said.

Senator KITTREDGE. It is about 15 miles long?

General DAVIS. There are 9.38 miles there of uninterrupted lake navigation.

Senator KITTREDGE. And the longer section is about 15 miles longer than the Panama Canal?

General DAVIS. Oh, the whole length of the canal from ocean to ocean—

Senator KITTREDGE. No; I do not mean that. I mean from that lake in the central part, of which you are speaking.

General DAVIS. Lake Timsah is a turning point. There is a place where ships can turn around. It so happens that from Lake Timsah to Port Said is exactly 49 miles; and in that distance from Lake Timsah to Port Said there is no place where a ship can turn around, nor anywhere near turn around, unless it is a mere tugboat or something of the kind. It happens to be just 49 miles from Lake Timsah to this end. There is a point where they may turn [indicating] and so they may here [indicating the Bitter Lake].

Senator MORGAN. Does that Bitter Lake receive any contributions of water from the Nile or from any other great stream?

General DAVIS. None whatever, except from the Red Sea and from the Mediterranean.

Senator MORGAN. I know; but I mean did it naturally, before the canal was constructed?

General DAVIS. Oh, no; it was a dead sea; it was dry. It was a dry basin. So was Lake Timsah.

Senator MORGAN. It has been filled up by the water being let in from the Red Sea and the Mediterranean?

General DAVIS. Yes, sir.

Senator MORGAN. So it is now salt water?

General DAVIS. It is now salt water, and so is Lake Timsah.

Senator MORGAN. They were both dry basins before that canal was cut through there?

General DAVIS. Oh, yes. One of the arguments that was brought against the Suez Canal by those who were opposed to its being constructed was this: "Just as soon as you let the sea water into the Bitter Lakes and Lake Timsah the evaporation will turn the whole affair into salt, and you will have nothing there but a body of salt." That was one of the charges against it.

Senator MORGAN. That has not occurred?

General DAVIS. No, sir.

Senator TALIAFERRO. How far is it, General, from the Red Sea end of that Bitter Lake to the Red Sea?

General DAVIS. From here out [indicating]?

Senator TALIAFERRO. Yes.

General DAVIS. That is mile 64, and this is mile 90 or 91. It is about 30 miles. I shall come to that again.

Senator MORGAN. Practically 24 miles.

General DAVIS (reading):

"There is practically no limit to the number of vessels that can be passed; the present 'sidings' can be increased in number, but as the large Bitter Lake affords the means of shunting any number of vessels it is unnecessary to widen the canal. The fact that Her Majesty's troopships, vessels of 4,400 tons, 400 feet long, of 52 feet beam, and drawing 22 feet of water, pass through the canal in an average on 49 voyages of seventeen hours under weigh"—

A distance of 104 miles, remember.

"Their average time in the canal being about forty hours"—

That is, with the nights added, because at that time they did not have any electric lights to use in illuminating the place at night. In other words, the canal was not lighted. (Reading:)

"Affords a convincing proof of the sufficiency of the canal for all reasonable purposes and as a mercantile highway."

This report was written about 1884, when the bottom width of the canal was 72 feet and its depth 26 feet, and when the average capacity of vessels using it was but 1,500 tons. We have the tonnage; we know how many vessels passed; we know what they paid tolls on, and we find it averaged 1,500 tons. But the enormous increase in steam tonnage throughout the world and the increased size given to ships forced the Suez management to enlarge the capacity of the canal prism.

The Suez Canal has been in process of widening, deepening, and flattening of curves ever since it was opened, in 1869. Not a day has passed since then when they have not been taking out something, making it wider or deeper. They are doing it all the time; and I have some very interesting figures here about what it cost. And if there exists such paramount importance or advantage in having straight sailing courses, such as the lock people claim, why have not the curves at Suez, or even one of them, been changed according to the modern idea, as might easily have been effected? These French engineers are not asleep. They are as live men as you can find anywhere; and if this system of polygon navigation had been adapted to canal purposes those Frenchmen would have found it out long since. Instead, they have left every curve which was there originally. They have not taken out one. They have made them flatter; they have made the sweep longer.

This polygon navigation is absolutely indispensable in the Great Lakes, in the submerged channels. There they have to have it, and they do have it, and it works beautifully; and they have followed it in the Hay Lake channel and the Neebish channel and in other parts of the Great Lakes. But this canal as proposed by the minority is a system of lake navigation.

Another point which the Secretary makes is that the proposed Gatun locks are capable of receiving vessels 25 per cent—the minority say 40 per cent—larger than the new Cunarder, whose dimensions are 800 by 88 feet by 38 feet draft.

I want to say a word about this matter of the draft of ships.

If you take Lloyd's Register, which is the standard of all of the registers of shipping in the world—next to it comes the Bureau Veritas of the French—they never, in those books on classifying ships, give you the draft. They give you exact detail about the ship,

its length on the water line, its length over all, and its greatest beam; they will tell you how many horsepower its engines develop, who built them, where the ship was built, and everything else about it, but they never put anything about draft in those tables, because the draft is variable. That is perfectly well recognized. As you gentlemen all know, every foreign ship and a great many American ships have marked on them the maximum load line, sometimes called the "Plimsoll mark," but usually called the "Lloyds mark," which means that you must not load that ship deeper than that mark.

That is all that anybody can say about the draft of a ship. If you put more of the cargo forward and less astern she draws more forward. If you load more astern and less forward she draws more aft. So all we give in our Navy Registers about the draft of our ships is their mean draft, the ordinary, usual draft of battle ships and cruisers. That is very easy to state for those vessels, because when they are put in commission they are expected to carry a certain definite amount of weight. But these commercial ships are continually changing.

The reference to this Cunarder as having 38 feet draft—as given in the report of the Board—means that you must not load that ship so as to draw more than 38 feet; but probably not once in the whole lifetime of that ship will she ever be loaded so as to draw 38 feet.

One of the vessels that passed through the Suez Canal last year, the British battle ship *Terrible*, is put down in the Naval Register as drawing 30 feet, and yet she went through the Suez Canal drawing 26 feet. That shows how little dependence you can put upon the matter of draft, so far as the published reports are concerned.

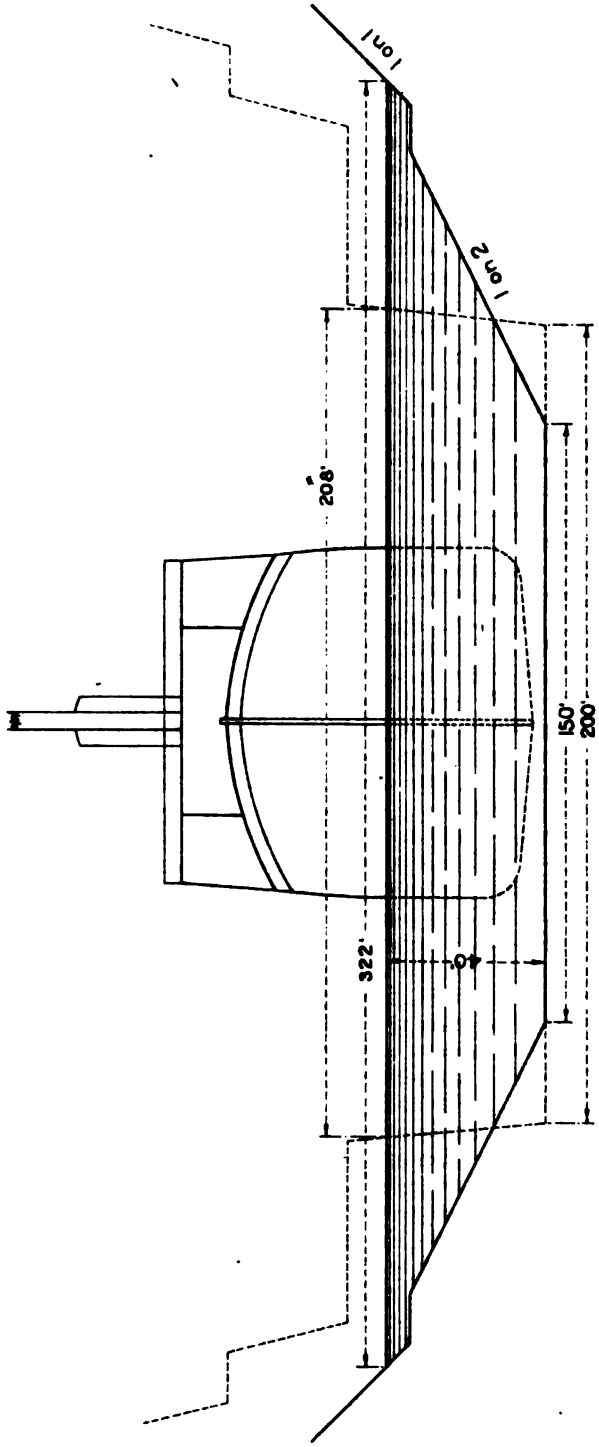
These locks, and all others proposed by the minority, are to have a depth on miter sills of 40 feet. At the end of the dry season the lake level is expected to be drawn down to Level 82, which will decrease the depth of water on the miter sills of the two upper locks to 37 feet, and this low-water period may continue for two months or more, or until the rains and floods restore the level of Lake Gatun to 85 feet. If the supposed Cunarder applied for transit with conditions as above, she would have to wait weeks or even months to be permitted to enter at all.

Again, it is well known that the draft of vessels is greater in fresh water than in salt. This is frequently stated for moderate-sized vessels at $3\frac{1}{2}$ per cent of the draft. With such allowance for increased draft of the Cunarder in the fresh water of Lake Gatun she would then draw $39\frac{1}{2}$ feet, and in entering the lock she would have only 9 inches of water between her keel and the miter sill. Would the owners of a 35,000-ton ship be willing to take the chances of escaping injury with a margin of but 9 inches to go on?

It seems to me that the question answers itself.

The minority may say, "But the majority plan calls for a canal only 40 feet deep, and that only leaves 2 feet of margin to go on," and they will also say, probably, that since it is proposed to spill into the sea-level canal the regulated flow of the Chagres River and some other minor streams, the waters of the sea-level canal will be fresh water and this same remark will apply to that type of canal. That is true if the premises are sound. But there is another condition that will result. If that water is let into the prism of the canal about its center, if the canal is at uniform sea level throughout its

SECTION IN EARTH ~ PANAMA SEA LEVEL CANAL



NEW CUNARDER "MAURITANIA"
Length 787.6' Beam 88' Draft 37'
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whole extent and the water is fresh, the ship will have her keel within 9 inches of the bottom of the canal. But that is based on the supposition that the water is all fresh. If, however, no water is coming into the canal, it will all be salt. Therefore she will have 2 feet of water under her keel. But if the coming in of the fresh water makes the water of the canal brackish (as it certainly will), and there is coming in 15,000 second-feet, which is what the majority estimate may be admitted without danger, what will happen in a hydraulic way? That water, piling into the canal at the rate of 15,000 second-feet—and that is a lot of water—will at once raise the level of the immediately contiguous portions of the canal until the water can escape, and it will continue to do so, and do so, and do so, and do so more and more, until, instead of the depth of your canal at that point where the Chagres water comes in being limited exactly to 40 feet, it will be 41 feet, perhaps. I do not know what the calculation would show, but it will be quite 41 feet, and it may be 42, and the slope to the sea on either side will take up the difference, and as the sea is approached the waters of the canal will become less and less fresh and more and more salt.

Senator TALIAFERRO. Do you understand, General, that this water from the Chagres will be let into the canal in sufficient quantities to raise the depth of the canal at that point?

General DAVIS. I am sure that letting in the water at 15,000 feet a second will sensibly raise the level of the water at the point where it comes in, and in a decreasing extent on either side. I do not believe anybody will dispute that proposition.

Senator TALIAFERRO. Do the majority estimate that?

General DAVIS. No; their plan is not based upon that idea at all.

Senator MORGAN. Could you not get rid of that difficulty by deepening the prism of the canal for a few miles?

General DAVIS. It could be done, sir, but I do not think it is a difficulty. I do not think it really is a difficulty. I do not think that this ship of 38 feet draft is going to appear in the Panama Canal in a generation, or in two generations, drawing 38 feet. The greatest draft of any ships entering New York to-day—these sixteen, seventeen, eighteen thousand ton vessels, twenty or twenty-two thousand ton vessels—is only about 30, 31, or 32 feet.

Senator TALIAFERRO. Still, you hold that if such a ship should offer to go through that canal she could be safely gotten through?

General DAVIS. We do; and there she is represented [indicating drawing]. There is 150 feet bottom width, and there is the *Mauritania*, one of the new Cunarders, with a draft of 38 feet. She has 2 feet of water under her keel. She is in the canal with a prism 150 feet wide. There she is represented.

Senator TALIAFERRO. And what is the beam of that ship?

General DAVIS. The beam of that ship is 88 feet, and this bottom width is 150 feet. Now, General Ernst had a sketch here showing two of these vessels lying side by side.

Senator KITTREDGE. It is over here, General.

General DAVIS. No; I took it down. That is mine; that is another. But there is no one that claims that two ships of 88 feet beam can pass in a 150-foot channel. Nobody claims that. Nobody pretends to assert that. This ship, if she did present herself, would have the road cleared for her. It would only be a matter of ten hours for her

to get clear through. Other ships could follow her and others precede her, but she could not pass at speed in any of the narrow parts of the canal unless passing places were arranged for, which would unquestionably be done. She would go through in ten hours as it is, and that is only at the rate of about 5 miles an hour.

Instead of a capacity in the locks for vessels larger than the new Cunarder, it is decidedly doubtful if, as planned, they are adequate for such a ship at all.

Another remark of the Secretary is to the effect that the sea-level canal, as planned, does not fulfill the conditions of the statute so as to afford "convenient passages," etc.

If, in the 21 miles of canal where the bottom width is 150 feet, meeting with the 88-foot-wide vessel by other ships were not permitted for two or three hours, the ship of 38 feet draft would find convenient passage; and this remark applies only to vessels of similar size. By the time the number of such vessels desiring transit reached considerable magnitude the canal would have been widened as would be found necessary; and the cost would be moderate, reaching, for the whole line, as estimated by the Commission, \$870,000 per foot of increased width. The Commission estimates that it will cost \$87,000,000 to widen the sea-level canal to 300 feet throughout. As estimated by the minority, omitting the 4.7 miles at Culebra, the cost is about \$500,000 per foot—that is, \$50,000,000 is the estimate of the minority for widening the sea-level canal to 300 feet in all places except the 4.7 miles at Culebra, certainly not a prohibitive cost to the United States.

Senator ANKENY. What is your estimate of the cost of carrying the Culebra Cut to the width necessary in addition to the other estimate?

General DAVIS. I have not figured it, but I presume that the figures of the Commission are about right; they figured up \$87,000,000 for the whole line.

Senator TALIAFERRO. Including the Divide?

General DAVIS. Including the Divide; and the minority of the board estimate \$50,000,000 for widening all except Culebra—4.7 miles.

Senator KITTREDGE. Was that action unanimous?

General DAVIS. No, no; that is an estimate of the minority. That is found in the minority report.

Senator KITTREDGE. I remember.

General DAVIS. The majority did not discuss that phase of the question. They believe that a canal 150 and 200 feet wide is wide enough for all purposes of navigation for the next twenty years; and when the time comes that we need more capacity, we will anticipate it and be ready for it.

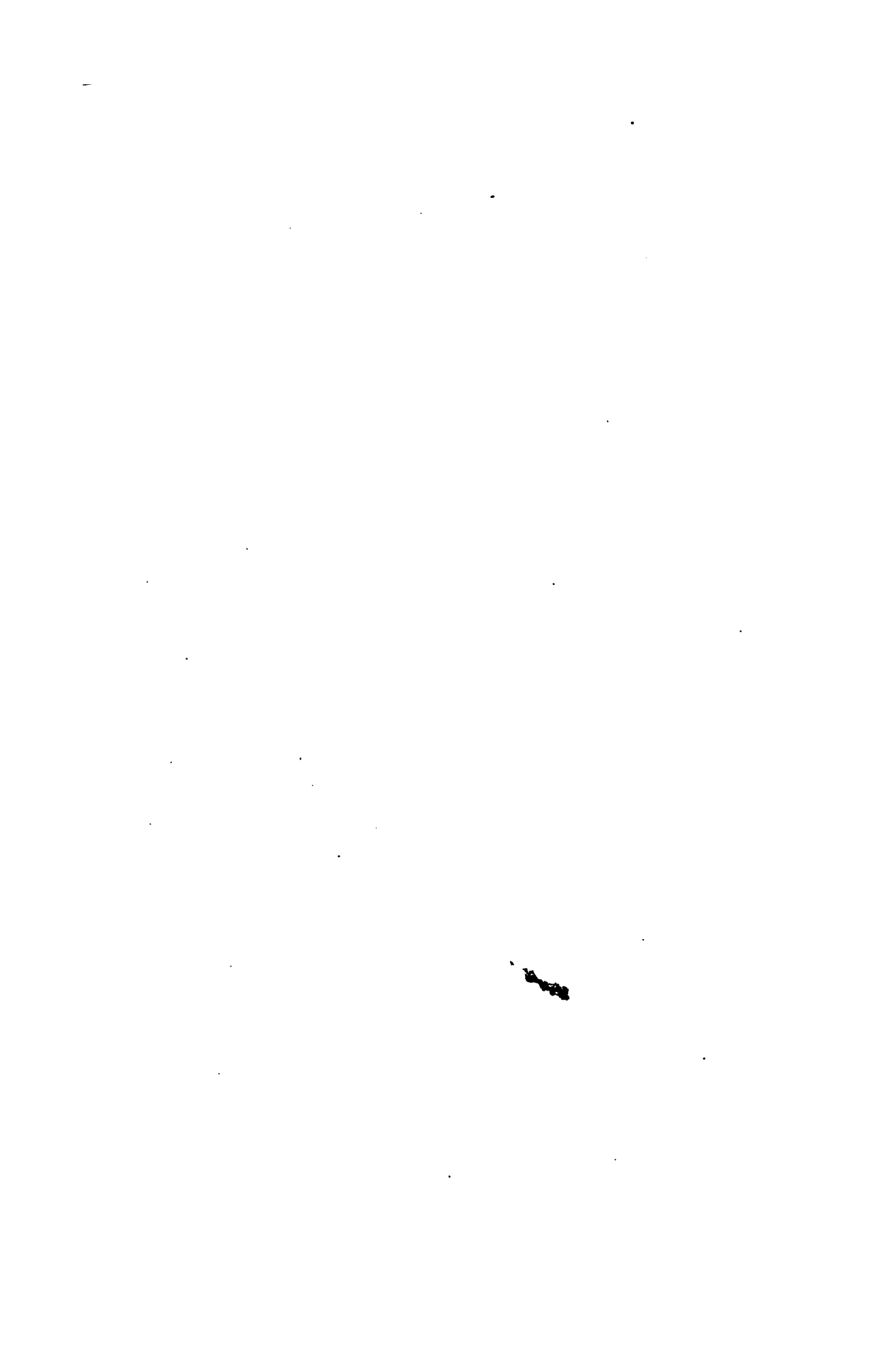
Senator MORGAN. That means 150 feet at the bottom and 200 feet at the top?

General DAVIS. No; 150 feet at the bottom in the lower portions and 200 feet at the bottom in the rock portions—that is, 150 feet in earth and 200 in rock.

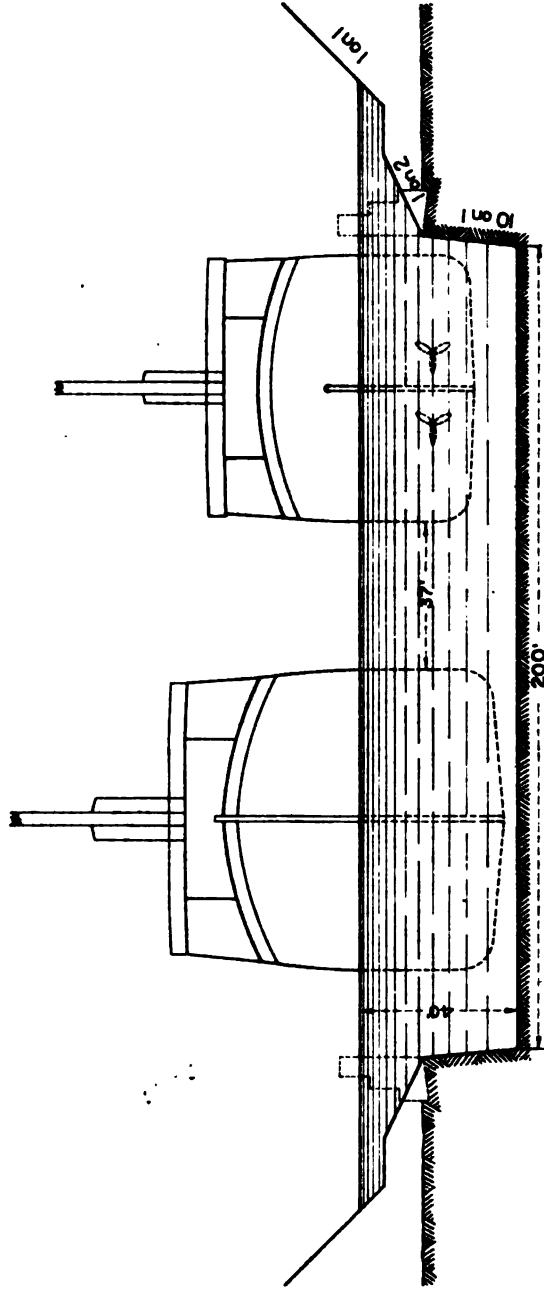
Senator TALIAFERRO. What would be the top width of that 150-foot part of the canal—that part that is 150 feet wide at the bottom?

General DAVIS. It would be nearly 300 feet wide from this point to that point [indicating].

Senator MORGAN. On the surface?



ROCK AND EARTH SECTION - PANAMA SEA LEVEL CANAL **WITH RETAINING WALLS BUILT TO ABOVE WATER LEVEL**



CELTIC

Length 679.4' Beam 75'

Draft 36.5' Tonnage 20904

Celtic Moving

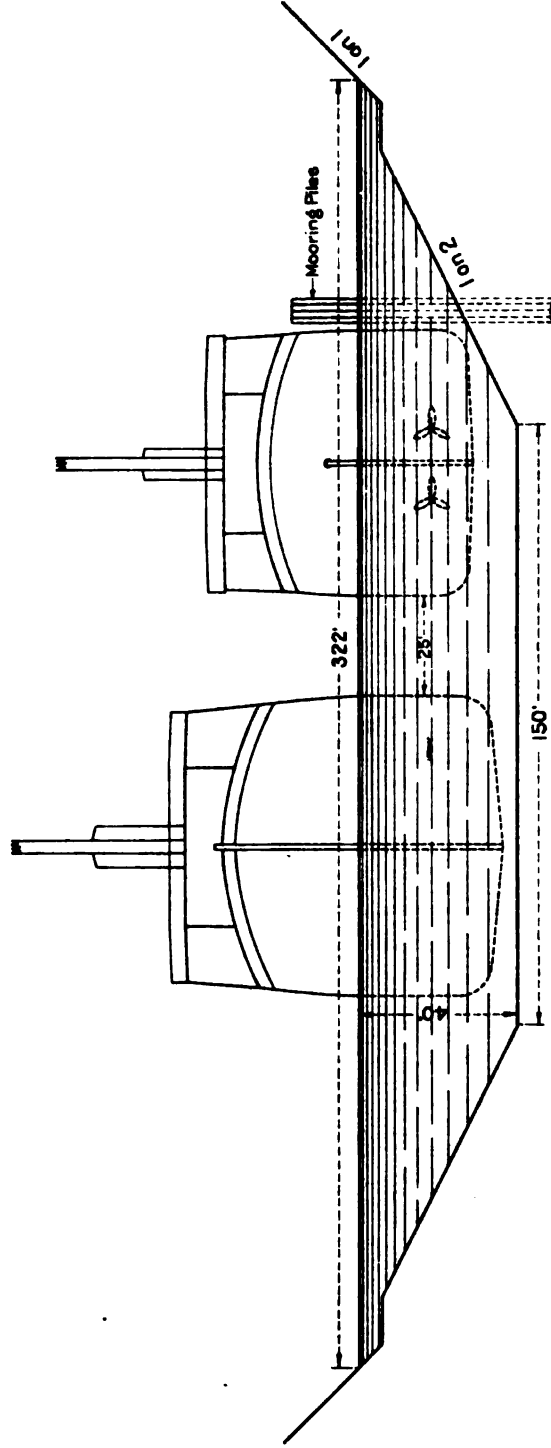
KAISER WILHELM DER GROSSE

Length 648.4' Beam 66'

Draft 29' Tonnage 14,349

Kaiser Wilhelm Moored

SECTION IN EARTH-PANAMA SEA LEVEL CANAL



CELTIC KAISER WILHELM DER GROSSE

Length 697.4' Beam 75' Length 648.4' Beam 66'

Draft 36.5' Tonnage 20,904 Draft 29' Tonnage 14,349

Celtic Moving

Kaiser Wilhelm Moored

General DAVIS. On the surface; and 150 on the bottom. Now, these two sketches represent two ships. This represents the *Celtic*, a White Star boat. She is 680 feet long and has a beam of 75 feet, and her gross tonnage is 20,904. That is the *Celtic*; some of you may have crossed in her. Now, this [indicating] represents the *Kaiser Wilhelm der Grosse*, of the North German Lloyd Line. Her length is 626.7 feet, her width is 66 feet, and her tonnage 14,349.

That sketch represents this ship as waiting for that ship to pass [indicating]. This ship is stopped on the side, and the lines are carried ashore and tied up to mooring piles, waiting for this one to go by. Now, the majority claim that that is perfectly practicable, and that the delay which will result from this crossing is inconsequential. I will read you a telegram from the chief engineer of the Suez Canal that was written to me a few days ago, in which he says that in the case of these big battle ships that are going through Suez now the average detention of those ships in the whole canal of 104 miles, due to the mooring idea—the idea of tying up ships to pass—is an hour and a half. I have here his original telegram.

Senator TALIAFERRO. Is that the detention as to the ship that ties up?

General DAVIS. It is the average of all. I asked him specifically the question, "Taking your big ships, what delay do they encounter, over and above the small ones, in this tying-up business?" He said: "It makes no difference. It amounts to an hour and a half per ship for the whole fleet that passes through there, and that is 13,000,000 net tons."

Senator TALIAFERRO. The delay here would only occur where there was an unusually large ship to be met?

General DAVIS. That is all. I admit, in this case, that while that ship is passing the 150-foot channel, nothing except quite small ships could be tied up alongside. That is quite true, that is quite the fact, while that ship is passing. You perhaps can not quite see it, but there is the 200-foot channel also plotted there, superimposed on the other.

Senator TALIAFERRO. Yes.

General DAVIS. It comes over to here. Now, in that channel, shunting this ship over so far on this side, a small vessel of three or four thousand tons could be tied up there, and the other could go by. There is not any trouble at all about that. But two ships of this size could not pass with a bottom width of 150 to 200 feet. This is what would happen, however, if the channel was made 300 feet wide: There [indicating] is a 300-foot channel, and there is the *Celtic*, and this is the *Kaiser Wilhelm der Grosse*. Now, that ship is tied up; this one is proceeding.

Senator MORGAN. That appears to be in the Culebra cut.

General DAVIS. Yes, sir; that is supposed to be in the Culebra cut. That is on the idea that you have got a width of 300 feet, and the material is rock.

The CHAIRMAN. What is this one here, General? [Indicating.]

General DAVIS. That is the same idea in a prism where it is part rock and part earth. One of the witnesses before the Board spoke of the disadvantage that would result from the fact that the corner of the rock would impinge against the side of the ship and be a source of great danger. This shows the idea that would be carried out

there—simply a retaining wall built up out of the water, sitting on this rock, which is not a serious matter. In fact, the Isthmian Canal Commission of 1899–1901 proposed to put a retaining wall through the whole stretch of the Culebra cut.

The CHAIRMAN. One ship would be tied up in this case, would it not?

General DAVIS. One ship would be tied up in that case; but the canal is wide enough so as to tie them up anywhere. They can be tied up at any place where there are groups of piles to tie to.

Senator MORGAN. Mr. Chairman, I suggest that before this report is completed, when the the revision of it takes place, we ask General Davis to explain these diagrams, and put the diagrams in the record. I suggest that we ask him to explain them so that they can be printed, and the Senate can get some ideas which can not be communicated merely with words.

The CHAIRMAN. Do you not understand that he is now making an explanation to the stenographer which will go right into the record at the present time?

Senator MORGAN. Yes; it can go right in now.

The CHAIRMAN. But is not the General's explanation sufficient now, as he is going along? Did you want something additional?

Senator MORGAN. I doubt very much whether it is sufficient, because the stenographer is obliged to put in the words "indicating," "indicating," which mean nothing.

The CHAIRMAN. And you would like to have the General, in addition to what he is stating now, explain the diagrams?

Senator MORGAN. Yes; I would like to have the diagrams put in, and explanations inserted by General Davis as to what they refer to and what he proposes to illustrate by them.

Senator TALIAFERRO. And to give particularly the top width of the canal at every point.

Senator MORGAN. Yes. Then the Senate can have a view of it in a picture, as well as in the description.

The CHAIRMAN. In addition to the explanation, as it is going on now, you would like to have General Davis give the difference in width of the 300-foot channel, as well as the 150-foot channel, would you not?

Senator MORGAN. Yes; every particular that he has alluded to.

The CHAIRMAN. General, can you do that for us?

General DAVIS. Oh, yes.

Senator DRYDEN. General. I was called out before you explained that matter, and I would like to ask you just one or two questions there. What is the width of the canal at the point illustrated by that diagram?

General DAVIS. By this diagram?

Senator DRYDEN. Yes.

General DAVIS. One hundred and fifty feet bottom width and about 300 feet at the surface.

Senator DRYDEN. And what is the beam of those vessels represented there?

General DAVIS. That ship is 75 feet beam, and this one is 66.

Senator TALIAFERRO. Just tell the Senator what ships they are.

General DAVIS. This is the *Celtic*, and that is the *Kaiser Wilhelm der Grosse*.

Senator DRYDEN. We had presented to us a day or two ago a similar diagram showing, I think, the proposed new Cunarders?

General DAVIS. Yes, sir.

Senator DRYDEN. And that diagram showed those ships almost touching?

General DAVIS. Yes, sir; yes, sir.

Senator DRYDEN. I would like to have your views on that matter.

General DAVIS. This is the 150-foot bottom width of canal, and in dotted lines is also shown the 200-foot width. Both are represented; one is overlaid on the other. And that is the *Mauritania*, one of the new Cunarders. She has 88 feet beam, and she is supposed to have 38 feet draft, which practically she never will have; but it has been shown here as a 38-foot draft. Now, I stated to the committee during your absence, Senator, that I did not pretend that two ships of that size could pass each other in the canal at the same time. I do not pretend that. Nobody of the majority does pretend it; but they do claim that when such a ship is to pass through the canal the canal company or the Government controlling the canal can very well afford to arrange ahead by telegraph to have all large vessels that are proceeding in the opposite direction lie by in the sidings until she gets through. It is only a matter of a very few hours, and since the whole transit for this ship will only take ten hours, it is an insignificant matter—quite insignificant. It is a matter of delaying some of the other vessels just a few hours.

Senator DRYDEN. When you said a moment ago "lie by only a few hours," you meant a few minutes, did you not?

General DAVIS. A few minutes each; but I meant a very few hours in the aggregate.

I also stated, I think during your absence, that I had been informed by a communication from the chief engineer of the Suez Canal that the average time of detention of all vessels, large and small, in the Suez Canal, due to the fact that they had to be tied up from time to time to allow others to pass, was an hour and a half. That whole business of mooring increased the length of the journey through the canal by one hour and a half; and that is all it signifies.

Some stress has been laid by the minority on the fact that the majority plan does not cover the estimated cost of providing these mooring places and equipping them, and has not made a charge in the report for their maintenance. Mr. Quellenec, who gave me this information about Suez, says that the entire expense of the twenty-three sidings in Suez, ten of which were equipped with telegraph and electric light, etc., is \$60,000 a year—the entire expense of all of those sidings. At Panama, even in the view of the minority, they only designate seven as necessary. The expense for those sidings might reach \$15,000 a year.

Senator ANKENY. Is it not true, General Davis, that in either canal no vessels would pass going in opposite directions at speed?

General DAVIS. No large vessels would pass at speed.

Senator ANKENY. They would never pass each other at speed in either canal?

General DAVIS. Until you have a width of considerably more than we have provided for in the sea-level canal. But the small vessels can pass readily, either at speed or by slowing down.

Senator ANKENY. But they never would attempt to pass one another at speed. They would have to stop in any event, even if they had a canal 1,000 feet wide?

General DAVIS. One would tie up or they would proceed slowly.

Senator ANKENY. That would be the way it would be done?

General DAVIS. Oh, of course it would be so.

In the minority report, on page 86, there is a tabulation which shows the effect of locks and sea-level upon time of transit. It is stated that a type C vessel, which is supposed to be 540 feet long and 60 feet beam, will go through the sea-level canal in eight and nine-tenths hours, and that she will go through the lock canal in nine and five-tenths hours—that is, supposing her to be one of 10 ships for the daily transit. Supposing her to be one of 10, and no more, she will go through a sea-level canal in eight and nine-tenths hours, according to the minority, and nine and five-tenths hours in the lock canal, according to the minority. Now, they say that when that business increases so that there are 20 ships a day of type C, 540 feet long, it will take ten and one-half hours for each one of them to go through the sea-level canal, and it will take here nine and seven-tenths hours to go through a lock canal. In other words, it will be eight-tenths of an hour against her, supposing there be 20 ships a day.

I have made a little calculation to show what that really means. On the theory that there are 20 ships in a day three hundred and sixty-five days in the year, it means 7,300 ships, all of type C—that is, of ships 540 feet long. Now, a ship of type C has a net tonnage of about 9,520 tons. That is about her net tonnage. That is about the tonnage she would pay tolls on, because the ratio between net tonnage and gross tonnage is about in the ratio of 13 to 18. Her gross tonnage would be 13,182 tons, and her net tonnage 9,520. Now, if there were 7,300 of those ships to go through the canal in a year, what would it amount to? It would amount to 69,460,000 tons for just that one kind of ship.

It is perfectly preposterous that there should be any such number of ships of that type to go through the canal. It may be that now there are three or four or half a dozen a year going through Suez. There are a few; there would be a few in Panama. But for the purpose of showing the effect of locks upon this question of delay, and assuming that there are 15 or 20 ships per day of that size, you are demonstrating something that has no applicability to our problem at all, because there would not be any such number of ships. There could not be. It is beyond human reason that there should be.

The Secretary has another observation, which is that "lock navigation is not experimental." But I say that any lock is a cause of delay, an obstruction, a danger. No locks of the lift proposed have ever been constructed. Locks in an interoceanic canal should not be permitted unless the topography and the financial resources of the canal proprietor forbid the sea-level plan; and these objections do not obtain at Panama with the United States as proprietor.

The reasoning which the majority have given in their report as to why they are opposed to locks is so clearly stated, so forcibly stated, that it would be supererogation on my part to repeat it. I think it is sound and logical and forceful. It seems to me that it is hardly necessary to say a word about that. That locks are necessary in

some places is, of course, true; and when they must be used in certain localities they are tolerated. We are delighted with the Soo Canal, with its present arrangement of locks. It is an admirable arrangement. Nature did not permit any other arrangement. We have to use them; and they are beautifully managed, economically managed; but we would not have them if we did not have to. If we were not obliged to, we would not have them.

Senator TALIAFERRO. In other words, locks are used to overcome difficulties that can not be overcome in any other way?

General DAVIS. Exactly so; and they are sometimes used a step beyond that. They are sometimes used to establish a convenience.

Take the great harbor basins in Europe—Liverpool, Bristol, London, Cherbourg, Havre, and all of those in the north of Europe, except around in the Baltic—they have a tide of 20, 25, 26, 27 feet. In a great many of the great harbor basins in Europe if ships were put formerly where the basins now are the tide would run out and leave them aground. They have overcome that difficulty by fencing in these great harbor basins and putting locks in front.

Senator TALIAFERRO. That is a fault or difficulty that can not be overcome in any other way, is it not?

General DAVIS. That is a difficulty that can not be overcome in any other way, except that they could lighter their ships; they could handle all their cargo by lightering, the same as they do in Hongkong and Singapore. But, I say, there it is done to effect a convenience.

Another proposition is that "the weight of dams insures compression of the mud and clay upon which they are founded."

I say that the depth of the compressible base changes abruptly as the two deep gorges are crossed by the dam at Gatun, this depth varying from zero to over 200 feet in four places, and within a very short distance on the dam's axis. It results that immediately alongside a spot where the compressible material is over 200 feet deep the base of the dam will rest on the incompressible indurated clay, but the dam at its highest point will be 135 feet above both classes of foundation. Mr. Stearns thought the total settlement might reach 2 feet, one-fourth of this after the dam was completed. If this settlement should occur over the margins of these precipitous subterranean geologic gorges there would be a tendency or a liability of the earth mass that settled to break away from the part that could not move. The tendency would be for a fault to occur—that word "fault" is used in the geologic sense—which would be a vertical fissure or plane of movement or weakness extending through the dam transversely from its base to its crest.

If a compression should occur such as is counted on as a beneficent feature the opposite would result and a danger would exist.

Senator MORGAN. General, may I ask you a question that is interesting here? You mentioned these "geological gorges." Is there any authority that you know of amongst scientific men, amongst geologists, for denominating those as geological gulches or geological gorges?

General DAVIS. It is a name that has been applied to them by all the writers that have talked about the canal problem at Panama ever since it began to be discussed by scientists. There have been, I think,

four groups of scientific observers at Panama. One is a gentleman whose name I can not recall, connected with the University of California, who made a visit to the Isthmus many years ago and wrote a report on the geology of the Isthmus. Another was Mr. Hill, connected with Harvard University, who visited the Isthmus ten years ago, I think, and wrote a book on the subject of the geology of the Isthmus.

Senator MORGAN. That report is among the papers of this committee.

General DAVIS. No, sir; not the report of this Board; no. The next observers who wrote a report were two Frenchmen—Zurcher and Bertrand. They went there at the time the new French canal company was endeavoring to put its scheme on its feet and get money to build the canal. They are distinguished scientific men, distinguished in their own country, and their opinion is regarded as deserving of attention. Their report is printed in this book, translated and printed. They had before them, when they wrote that report, all that Mr. Hill had written, and all that the California geologist had written; and they discussed the geology of the Isthmus from those standpoints. These, and other writers, speak of that geological gorge at Panama; they all refer to it by mentioning it as the probable bed of a prehistoric river which flowed into the sea when the land was at least 300 feet higher than it is now with respect to the ocean. They all refer to it in that way, and we have taken up that term from those reports.

Senator MORGAN. That is to say, they are gulches that have been washed out by water?

General DAVIS. Washed out by water when the land was higher with respect to the sea than it is now.

Senator MORGAN. And not formed as a part of the original crust of the earth there?

General DAVIS. Oh, no. The land may have been a great deal higher than it is now; we do not know how high. It is a well-known fact that the Hudson River bed extends about 400 miles out into the Atlantic Ocean. You can trace it three or four hundred miles, clear out to the Gulf stream; so that the land was once a great deal higher than it is now.

Senator MORGAN. Yes.

General DAVIS. And so the Chagres River perhaps drained an isthmus that may have been many times as wide as the present Isthmus is.

Senator MORGAN. The point I was trying to trace was as to whether or not those gulches are attributable, according to the common consent of all who have examined them, to the attrition of water?

General DAVIS. Oh, there is no question about that. I do not think there are any two opinions on the subject.

Senator MORGAN. That is the point I wanted to get at.

General DAVIS. Another remark of the Secretary speaks of navigation under the sea-level plan as being conducted "through a comparatively narrow gorge." He speaks of difficult navigation on account of the narrowness of the gorge at the Culebra.

So far as concerns navigation, a channel with banks 1 foot high is no more and no less convenient than one with banks 1,000 feet high. It seems to me that that is palpably the fact.

The Secretary says, as a disadvantage to the sea-level canal, that the vessels can not turn about. That is, it is assumed that a vessel gets started and for some reason wants to go back, or an obstacle is found to interpose, some accident has happened, and passage through the canal is interrupted, and it must go back.

I say that only in case of closing the canal through some accident could it be necessary for a ship to turn about. Should it be desired to withdraw a ship from the sea-level canal, she could be backed out or withdrawn by tugs, just as has been or can be done from the 49 miles of the Suez Canal (which is 118 feet wide at the bottom with a minimum width of 108 feet) from Port Said to Lake Timsah, in which distance there is no place to turn about. That is to say, it so happens at the Suez Canal that there is exactly 49 miles (the same length that we have on the Isthmus) where no ship can turn around and where, when an accident happens, the ship has to be backed out, as has been done and would have to be done anywhere.

Senator MORGAN. Ships can be safely navigated stern foremost, can they not?

General DAVIS. Oh, it could be done, but very slowly, of course; and the steering would be difficult.

Senator MORGAN. But I said "safely."

General DAVIS. Oh, yes—safely; yes, sir. It could not be done with their own steam, I think. They would have to be handled with tugs and carefully guided.

The next point is the "greater safety of ships in a lock canal."

If this claim is sound Suez would be safer if it were equipped with locks. It would be very difficult to convince the Suez management of the soundness of this proposition.

It is said that the estimate of the majority is too low by at least \$25,000,000.

The Commission give definite figures for this alleged deficiency. The items are, underestimate of cost of streams except the main Chagres, \$7,800,000; underestimate of cost of the Culebra excavation below +10, \$17,159,418; total, including 20 per cent contingent, about \$25,000,000.

The majority have expressed their opinion, and no sufficient reason has been advanced to change their figures. The whole Board of 13 men are responsible for the estimate so far as relates to the Culebra excavation; that is to say, that the Culebra excavation would involve the removal of a certain number of yards of material, which was ascertained to be 110,000,000. The whole Board of Consulting Engineers fixed certain unit prices. They all agreed that those unit prices were adequate to do the work.

Senator MORGAN. There was no dissent from them?

General DAVIS. There was no dissent from those unit prices. Now, the majority found out that there was 110,000,000 cubic yards of material there; that a certain part of it was above +10, and we multiplied that by 80 cents; that another part of it was below +10, and

we multiplied that by \$1.25. That is the way we got our figures, and that is exactly the way the minority get their figures for their excavation of Culebra. So that if there is any inadequacy of estimate there, 13 men have made a mistake—not 8, but 13 have made the mistake.

Senator MORGAN. That would apply equally to the lock canal?

General DAVIS. And that applies just exactly the same to the lock figures as it does to the sea-level figures.

Senator MORGAN. The unit figures are the same for both?

General DAVIS. Exactly the same; exactly the same.

Senator TALIAFERRO. Except as to the locks?

General DAVIS. No; I am only speaking about the inadequacy of these figures for this excavation at Culebra. No; I did not touch the locks.

Senator MORGAN. I am referring to the excavation through the Culebra heights.

General DAVIS. And everywhere, Mr. Senator; everywhere. It applies everywhere.

Senator MORGAN. I particularly had in my mind the question about the Culebra heights.

General DAVIS. Yes, sir.

Senator MORGAN. Because that is the most difficult part of the work. I understand you to say that all of the Board agreed upon the unit prices that you have stated for excavation through that part of it?

General DAVIS. Through that part and every other part.

Senator MORGAN. And every other part?

General DAVIS. Through that part particularly; yes, sir.

Senator MORGAN. And a minority who favor the lock system in their report adopted the same unit prices?

General DAVIS. Exactly; yes, sir.

Three engineer members of the Commission and Mr. Stevens oppose the sufficiency of this estimate. One member of the Commission concurs with the whole Board. The division therefore results, 14 in favor and 4 opposed to the sea-level estimates as respects Culebra. Besides, one member [Mr. Randolph] of the minority of the Board is on record (page 137 of the report) as expressing the opinion that the sea-level canal can be completed within the estimate.

So far as concerns the adequacy of the sea-level figures for the cost of controlling the subsidiary streams, the tally would seem to stand, in favor, the same eight members of the Board and one of the Commission, or nine in all; opposed, five of the Board, three of the Commission and its chief engineer, or nine in all. Or, if you add Mr. Wallace to the majority side, it stands ten to nine. In analyzing these numbers the two nonengineer members of the Commission have not been considered.

As to the estimated time of construction—

Senator MORGAN. If you will wait just a moment, I wish to ask you about a fact that is in my mind, and that it will only take a minute to speak of. In both plans of the canal, as projected by the majority and by the minority—the one a sea-level and the other a lock canal—there is a berm left at the surface or just above the surface of the canal?

General DAVIS. Yes, sir.

Senator MORGAN. In both instances?

General DAVIS. Yes, sir; in both instances.

Senator MORGAN. Is there any difference in the width of that berm in respect to the two plans, the sea-level and the lock plans?

General DAVIS. No, sir; no, sir.

Senator MORGAN. They have the same width of berm?

General DAVIS. I think so, sir; that is my understanding.

Senator MORGAN. So that that berm, when it acts as a means of catching whatever may slip from above, is the same in both cases?

General DAVIS. Exactly; yes, sir.

The majority of the Commission and the minority of the Board think that a sea-level canal will require from fifteen to twenty years and the lock canal nine years. The sea-level task is a plain, simple task of excavation and removal, there being of what may be called "works of art" an item of \$6,920,000 for the tide lock and accessories, while in the lock project there is allowed for similar structures, such as locks, sluices, spillways, moval dams, etc., \$35,267,000.

Senator MORGAN. Right there I think it is appropriate to ask a question about this sea gate. Some of the engineers who have been before us say that by digging the sea-level canal in from the 40-foot contour in the Bay of Panama, with a width of 300 feet (I think that is the way they projected it), the sea gate could be dispensed with.

General DAVIS. Men have expressed that opinion; yes, sir.

Senator MORGAN. Is that your opinion?

General DAVIS. I should hardly be willing to adopt it, with the information that I have and, I think, with the information that exists, because the data to enable one to pass upon that subject is not satisfactory. The currents in a waterway are governed by so many conditions that it is difficult to predict what those currents will amount to in velocity unless you have perfectly well-known conditions. There is an engineer in New York, who is chief engineer of the city of Brooklyn, who has written to every member of the Board and to a great many other people, stating that in his opinion this tide lock is not necessary at all. It is not at all necessary, he thinks. He cites the opinion of a Frenchman by the name of Boussinesq, of the French Academy, who some eighteen or twenty years ago made a report on that subject for Mr. De Lesseps, and he expressed the opinion that the currents in the Panama Canal at the Panama end would not exceed 3 miles an hour. I think that was the figure.

Senator MORGAN. At high tide?

General DAVIS. At high tide, or rather at the time of greatest tidal flow.

Senator MORGAN. Yes.

General DAVIS. Because at high tide it is slack water, and the same at dead low water.

Senator MORGAN. At the time of greatest pressure, in other words?

General DAVIS. Yes, sir. Now, a member of the Board, wishing to get light on the subject, consulted a college professor who was thought to be a very competent hydraulician, and gave him the facts concerning the Panama Canal—told him how wide it was proposed to make the canal prism, what distance it was across, and how much the tidal oscillations were—and asked him to compute the current that

would be derivable from this range of tide, and where that current would have greatest velocity. This professor made a calculation and submitted it, and demonstrated to his own satisfaction that there would be a current of—I have forgotten now; I think it was 9 miles an hour—and that the greatest velocity of that current would be at Colon, 50 miles from Panama, at the point where the Panama Canal entered the Atlantic Ocean. The whole thing was so absurd that even the gentleman who had invited the opinion rejected it as useless. And so it is a subject beset with a good many difficulties.

In the Manchester Canal there is a somewhat analogous case. The Manchester Canal enters the Mersey just above Birkenhead, just above Liverpool. Liverpool has a maximum tide of 22 or 23 feet, and the tidal oscillation at the point where the Manchester Canal takes out of the Mersey is quite 20 feet—that is, quite as much as it is at Panama for the Panama Canal. Mr. Hunter, who was a member of this Board, and who is in charge of the Manchester Canal, and, indeed, who was in charge during its whole time of construction, said that he was satisfied from his observation of the current at Manchester that a tidal lock would be necessary a part of the time at Panama with a canal of the prism which we proposed.

It goes without saying that if that prism be made wide enough we could encounter that current without any difficulty. That has been pointed out by good engineers. For example, the Harlem River, which joins the Hudson and the East rivers, is a tidal estuary through which our own Government has done a great deal of work in straightening the channel and in constructing a canal for navigation between the Hudson and the East River without going around the Battery. The tide there has 8 or 9 or 10 feet oscillation, and boats pass and repass without any trouble through the Harlem River.

That is about all that I can say to you on the subject, except to call your attention to Suez, which is an object lesson in many ways. The tidal oscillations in the Red Sea amount to about 7 feet or 8 feet, as a maximum. There is occasionally about 8 feet of tidal oscillation twice a day. That tide is felt as far as Tossoum, 12 miles from Suez; there it disappears. It practically is felt up to the opening of what is called the Little Bitter Lake, and there it disappears. Now, that current is variable through this portion of the canal, and at times of extreme tidal oscillation it reaches 3 miles an hour at the point of exit, and varies from that all the way up. But Mr. Quellenec says that that furnishes no obstacle to navigation; that vessels pass and repass in both directions, only they observe this rule—that when a ship is going with the current she is never stopped; it is the vessels that are going against the current that are tied up to allow the others to pass. But it furnishes no impediment.

Senator MORGAN. Is it therefore possible, in your opinion, by widening the prism of the canal sufficiently, say to 400 feet, out to the Bay of Panama, from Pedro Miguel or Miraflores, to dispense with the tidal gate?

General DAVIS. I think it is decidedly probable. That is as much as I would dare to say—that it is decidedly probable that it would be so.

Senator MORGAN. Or, if a basin were formed at the foot of the hill there, at Miraflores or in that vicinity, say twice, three, or four times

the width of the canal on its surface, it would probably impede the flow of water from the bay when it is filled up, just as the Bitter Lake does?

General DAVIS. No, no; the tidal flow will be less the less the area into which the tide piles up—that is, if you have a big lake here connected by a tidal lock with the sea, and that had to be filled and emptied twice every tide—suppose that was the case—the amount of water that would pass through this tidal lock would be enormously greater than it would be if it only had the canal prism to fill up. If the storage for water was limited to the canal prism, it would soon be filled, and then there would be nowhere for the water to go. But if you had a big lake here you would have to fill that lake and empty it twice a day, and all the water would have to pass in or pass out through that tidal lock, and it would take a terrific current.

The smaller the area of the prism which has to be filled by water and the wider the opening through which it may be filled the smaller will be the current to be encountered in navigation.

Senator MORGAN. The difficulty I am trying to overcome in my mind, General, is just this: That a tidal gate there is subjected not only to the ordinary pressure of the ocean, coming in at 20 or 21 feet of high tide twice a day, but also to the effect of the increase of the inflow of the water from the Bay of Panama by storms that occur there, sometimes of immense rapidity of movement.

General DAVIS. I was there a year, Senator, and I never saw a wind that amounted to more than a pleasant breeze.

Senator MORGAN. But there have been storms there.

General DAVIS. I never have heard of one. I have never heard of a gale in Panama Bay.

Senator MORGAN. I can get you the record of it.

General DAVIS. Have you that?

Senator MORGAN. Yes.

General DAVIS. I have not seen it.

Senator MORGAN. They are very terrible when they come, and they occur perhaps three times in a century.

General DAVIS. Well, I have not happened to observe the record.

Senator MORGAN. I simply had those things in my mind, and I was trying to find out about them.

Senator DRYDEN. General, I was going, before you concluded your testimony, to ask you a question upon this very same point that Senator Morgan has brought out; and I think it is apropos now to say that I have a letter from a very distinguished hydraulic engineer of my State, Mr. Clement Herschel. Do you know Mr. Herschel?

General DAVIS. He is the gentleman to whom I referred when I spoke of having had correspondence.

Senator DRYDEN. Mr. Herschel has, in a way, been interested in this project ever since Mr. Burlingame returned from China as minister from China to the United States and Europe. The Chinese were interested in having this canal put through.

Senator MORGAN. Away back in the sixties.

Senator DRYDEN. Yes; about 1866 or 1867, Mr. Herschel writes me. And Mr. Burlingame then consulted Mr. Herschel about this project, and he has kept up his interest in a way ever since. He sent me the

proof of an article which will soon appear, if it is not now in print, in one of the engineering journals. Mr. Herschel believes that this sea-level canal, as designed and recommended in the majority report, can be built without a lock. He states here as a matter of interest that the construction of the Corinth Canal was prevented for two thousand five hundred years after it was first projected, because the engineers did not believe that it was safe to build a sea-level canal without locks. Then he refers in his article to the little canal at Tasmania, and also speaks of the Suez Canal—that it was thought that it must be protected in the same way. That is true, I believe?

General DAVIS. Oh, yes; those are all facts.

Senator DRYDEN. I would like to quote, in order to have it go into the record, an extract from Mr. Herschel's article, because I think it is interesting and illuminating on this subject. Of course you will understand that this is taken out of the body of his article.

"We have only these data: A slope of water surface on the Suez Canal $2\frac{1}{4}$ inches to the mile produced a maximum velocity of 2.67 feet per second (1.6 knots); and it will not require profound hydraulic computations to show that in a Panama canal which will have a maximum slope of water surface of 3 inches per mile on 44 or 45 miles of sea-level canal the engendered velocities will not be inordinately great. Again, the precise computations were long ago made by Boussinesq"—that is the engineer your referred to?

General DAVIS. Yes; that is the one I mentioned.

Senator DRYDEN (continuing reading): "And other masters of the science of hydraulics, and may be found in the records of the meetings of the French Academy of 1887, volume 104, page 1484, for the cross section of canal then proposed, and will not inordinately vary from those for the cross sections now proposed."

"The situation as found by Boussinesq and his fellow-members of the committee would be exactly similar to the one above described as existing in the Suez Canal—a long water surface, this time 45 miles long—hinged, as it were, at one end and the other end oscillating some 10 feet above and below the fixed mean level of the sea, making alternately a slope of water surface and of currents to the north and to the south about 3 inches to the mile of maximum slope, and maximum currents of about 4 feet per second (two and a half knots). On rare occasions during the year, brought about by strong gales, this may be exceeded, and there is room for the excess without materially obstructing navigation. Vessels do navigate channels having a 5-knot, 6-knot, and higher velocity currents up to 10 and 12 knots in narrow channels on river rapids."

That is an important fact.

"But it is not the purpose of this article to discuss the debatable questions; and the precise limit of speed at which currents become of material hindrance to navigation is such a question." etc.

Now, Mr. Herchel states in his article, as I read it here, that there has never been any exact calculation or measurement taken to ascertain the velocity of the inrush of the sea at different periods. That is correct, is it not, General?

General DAVIS. That is true. This Board wished very much to make such a study; but the study would have involved a good deal of time, and it was conceived that the Board would have finished its work in three months from the time it was created. It could not take up that subject of discussion, purely scientific study, and solve it or even arrive at any conclusion on it in the time that was available for its purposes. I think it is a subject that the present Isthmian Canal Commission or the chief engineer ought by all means to study with the greatest care; and there should be no pains spared to get every fact bearing on that question of the currents at Panama that is possible. We do know that in the case of the present canal entrance, which sweeps in here [indicating], and at the La Boca wharf, there is an excavated channel reaching clear out here [indicating], and ships have no trouble in coming to that wharf at any time of the tide, and there is a current going in and out there all the while. Even if that wharf had been put away down here somewhere near Miraflores, and the channel were made of the same dimensions, I do not see any reason why ships should not have gone up there to load and discharge if it were desired. There are ever so many facts that tend toward the conclusion that Mr. Herschel has reached.

Senator DRYDEN. If a sea-level canal should be built, whether it can be built with or without locks is certainly a very important question.

General DAVIS. Yes, sir; a very important one.

Senator DRYDEN. And I think that this contribution from the pen of an eminent hydraulic engineer ought to go into our records and be before us.

General DAVIS. I am very glad it will.

Senator MORGAN. Allow me to ask this question: If a sea-level canal were dredged out from, say, Pedro Miguel into the bay, could the question as to the necessity for a tidal lock or gate be determined after the dredging of that channel?

General DAVIS. Oh, yes.

Senator MORGAN. As well as before?

General DAVIS. Yes, I think so; because before you had the Culebra cut dug out you would have ample time to build the lock.

Senator MORGAN. That is it. So that is a question that for its final determination can be postponed even until after the dredging out of the canal from Pedro Miguel into the bay?

General DAVIS. Yes, sir; I think it unquestionably can.

Now, I want to say on behalf of the majority—and perhaps I might presume to speak on behalf of the whole Board, but I will not attempt to represent anybody but myself in this matter—that the

experience of Mr. Hunter at Manchester was what, I think, had more influence upon the Board than any other one thing. Quellenec's observations about Suez all tended toward the elimination of the idea of the necessity for that tidal lock. But when Hunter, speaking for a place where they had just such a tidal oscillation and where they had a canal into which ships had to go and come, reached the conclusion that those currents might reach 5 miles an hour at extreme high water and low water—or at the time when the current was running at its extreme velocity, I should say—the Board did not wish to go against such an opinion, and therefore they have included this provision and \$6,000,000 for building a tide lock which enters into that estimate. If it is not necessary, so much the better, but there is \$6,000,000 there for a tide lock.

I was speaking about "works of art" that were involved in the two plans and as affecting the time of completion of the canal.

The sea-level estimate carries \$6,000,000 for the Gamboa dam and a part (say two-fifths) of the amount allowed for diversion dams, regulations of contributory streams, diversion channels, and embankments. This part of the \$3,500,000 set aside for these objects is \$1,400,000, making a total for sea-level dams, including Gamboa, of \$7,400,000, while the minority allows \$9,551,000 for fixed dams, embankments, etc.

If the Gamboa dam should be built wholly of concrete masonry, and if its cost should be added to the previous total for sea-level works of art, the aggregate for all such will reach \$12,920,000, as against \$35,209,000, or nearly three times more, and the figures for dams required for the two types will be as follows: For the sea-level canal, minus the Gamboa dam, \$1,400,000; for the lock canal, \$9,551,000—the latter sum nearly seven times as great as the former.

The total concrete required in the Gatun locks is said to be 1,300,000 cubic yards, a much larger quantity than has ever been placed in so limited an area; while the total mass of concrete masonry for all locks and regulating works may reach quite 3,500,000 cubic yards.

The minority estimate the time required for the Gatun lock excavation at four years. There is about 4,000,000 yards to come out of that lock pit. They estimate the placement of the masonry at two and a quarter years and the installation of the gates at one and a quarter years, making a total of seven and a half years at most; while it is claimed that the Culebra excavation for the 85-foot level canal will take eight and a half years.

Considering the vast quantities of imported cement, lumber, iron, steel, and machinery required in lock construction; the fact that no sand suitable for concrete is known to exist on the Isthmus save on the sea beach at Panama—and it will take 1,500,000 yards of sand to be hauled for all those locks; that the Isthmus is from four to seven days' steaming distance from the nearest home port; that the rains will prevent outdoor work for about one-third of what we are accustomed to regard as working days; and, finally, that the Isthmus furnishes no skilled labor whatever, then the type of canal which will present fewest difficulties will be the one which calls for fewest mechanical constructions and least skilled artisans.

Eminent engineers have expressed the opinion that the feature of the lock canal that will take longest is the building of the locks, and

that the assignment of ten years to complete realization of the entire work is an irreducible minimum.

With the sea-level plan it is a matter of excavation and transportation than which there is no kind of construction work more simple; a kind of work for the doing of which improvements in tools, means and methods of transportation, and disposal may be more confidently expected than in carrying on the more advanced mechanical operations involved in building locks, lock gates, and movable dams.

The greatest practicable speed of construction obtainable is decidedly in favor of the simple work of digging a ditch joining the oceans at one level over that of forming an elevated channel 85 feet above the oceans in six steps.

In the building of the Suez Canal, toward the close, they made an average output of 2,000,000 yards a month at Suez; and that, you know, was thirty-seven or thirty-eight years ago, with tools and machines that were antiquated—wonderfully antiquated compared with what we have now.

You have all read about the drainage of the City of Mexico, or the valley of Mexico; and you probably remember to have seen, if you went down the Mexican Central to the city, that you pass through a huge chasm that was excavated by the Spaniards hundreds of years ago. It is called the Nochistonga drainage channel. It was commenced the same year that the first white man landed at Jamestown—the very same year, 1607; and it was carried to completion. The work was done by Indians, carrying out the earth in baskets, on their heads and on their backs; and they took out 54,000,000 cubic yards of dirt out of that cut, 12 miles long and over 200 feet deep. That was finished 150 years ago. It was not adequate, and since then they have gone and bored a tunnel through the mountain, and now they have a better system.

The maximum output on the Manchester Canal during its construction, in yards, was about 10,000,000 a month. The plant was limited, and Mr. Hunter said that with a larger plant they could have gone up to 13,000,000 easily, so far as finding a place for them all to work was concerned.

There is a mine in Peru called Cerro de Pasco that was opened up by the Spaniards hundreds of years ago. It is a silver mine. The ore has been taken out entirely by the natives, without machinery, carried up ladders on their backs and on their heads. That pit at Cerro de Pasco is 600 feet deep, 3 miles long, and half a mile wide; and that has been done by human muscle entirely. Culebra is not a circumstance to it. Of course we do not think of any such processes at Culebra. We propose to make steam and water power do that work instead of the hands of men, but it is not such a colossal undertaking. There is 110,000,000 yards to come out. The lock people are going to take out 53,000,000, they say. A little more than half will remain.

Senator MORGAN. That amount of 53,000,000 is down to 85 feet?

General DAVIS. In their 85-foot elevation they take out 53,000,000 yards at Culebra. We take out 110,000,000 yards at Culebra.

Senator TALLAFERRO. What did you say they took out at the lock foundations?

General DAVIS. Something less than 4,000,000 at the Gatun lock. [After examining papers.] It is 3,660,000 yards.

As to the Corinth Canal, which is only 2 miles or $2\frac{1}{2}$ miles long—Mr. Quellenec, the present chief engineer of the Suez Canal, who was a member of this Board, was the consulting engineer at the time the Corinth Canal was made. In that little, narrow, contracted space of only 2 miles they took out 2,500,000 cubic yards a year. And so these examples are found for the doing of something in reducing that Culebra Hill, which is now 165 feet high at the highest point. That is this elevation [indicating on map].

Senator MORGAN. You speak about taking out how many millions at the Gatun dam?

General DAVIS. It is 3,660,000 cubic yards in the lock pit. Oh, the Gatun dam?

Senator MORGAN. Yes.

General DAVIS. Not the dam. I mean the Gatun lock pit. If I said the dam, I did not mean it. No; I mean the lock pit at Gatun.

Senator MORGAN. There is something to be taken out, though, on the site of the Gatun dam?

General DAVIS. Oh, yes; they have to strip the site of the dam, and then they have to cut out the place for the diversion channel and the sluiceway to go through that hill.

Senator MORGAN. I understand. Now, is there any estimate in the report of the minority for the amount of material that has to be taken out, not including that through the hill?

General DAVIS. I think it is not stated in yards, but I think it is stated in money. I think they estimate a certain sum of money for stripping the surface where the dam is to be placed.

Senator MORGAN. So there is an estimate?

General DAVIS. In money; yes. I do not think it is stated in yards.

Senator MORGAN. That is all I wanted to know.

General DAVIS. I think it is all covered.

(The committee thereupon took a recess until 2.30 o'clock p. m.)

AFTERNOON SESSION.

The committee met, pursuant to the taking of recess, at 2.30 p. m.

STATEMENT OF MAJ. GEN. GEORGE W. DAVIS, U. S. ARMY (RETIRED)—Continued.

General DAVIS. The next point brought out by the Secretary's letter is: The cost of operation and maintenance, disregarding capital invested, is in favor of the sea-level canal, but is against it if the interest on the larger investment is allowed for.

My comment upon that is this: The minority, by a French method of computation, estimate the cost of maintenance and operating their six locks and sluices, representing 170 feet of lockage, at \$758,000, and the cost by the same method of computation of maintaining and operating the tide lock and sluice at about \$159,000, the total lockage being less than 21 feet, or less than one-eighth that of the multilock system. Assuming that the figure assigned for the tide lock is fair and that the cost for lock operation and maintenance would be directly as the lock-

age, then the cost of managing and maintaining the six locks should be \$1,382,000, or if cost should be assumed to be in proportion to the number of locks, the figure for the six locks would be about \$951,000.

The experience gained in the operation of the Suez Canal gives us some basis for inferring what may be the cost of some of the features of a sea-level canal at Panama. Suez is 104.8 miles long; Panama will be 49.35 miles long. The harbor at Port Said requires dredging well on toward a million cubic yards yearly. That is stated in their reports in many places. The harbor of Suez on the Red Sea requires no dredging to speak of. On the Mediterranean there is a littoral current that sweeps from the west to the east and that brings the sand along the shore, and so they built out a jetty, which is nearly 2 miles long. At first it stopped all the sand, but by and by the sand filled in between the jetty and the shore and they kept building out the jetty until they have it out now about as far as they think it prudent to go, and they have said that they can maintain the channel hereafter by dredging rather than extending the jetty farther. It takes about a million yards of dredging to keep that channel open.

Senator MORGAN. That much a year?

General DAVIS. Yes, sir.

Senator MORGAN. What do they do with the dredged material?

General DAVIS. Take it out to sea and drown it. If the Board plan for Colon entrance (majority and minority) is carried out, there will be very little dredging required to maintain the same. If the proposed jetty between the mainland and islands and outer harbor of Panama is built there will be no littoral drift and very little dredging at the Pacific terminus. Therefore Panama should be spared much expense of dredging harbors.

The total annual dredging at Suez for the last three years has been 3,414,000 cubic yards in maintaining the channel, and almost 1,000,000 of this was from Port Said entrance. That is from their official reports. The remainder, say, two and a half million cubic yards, was almost all blown into the canal by the desert winds. This is illustrated by this map. This is Lake Menzaleh. That lake formerly extended quite a little distance along here [indicating on map]. There are little hills sticking up all through it. In biblical times, according to the theory of those who have studied historical matters, this country was densely populated, and along here was the site of the city of Pelusium.

Senator MORGAN. The land of Goshen?

General DAVIS. That is what it was; but now that is a salt lake, and when this canal was built that side was the same as this side [indicating on map]. But prevailing winds from the east have filled in until one side here [indicating on map] is dry land and the other side is a salt lake. When the canal was made they were the same. Panama will escape any such obstruction, but whatever silt comes into the channel must be removed. All Chagres water that comes to the canal from Lake Gamboa will be clean and limpid; no water from the Gatun, Trinidad, Cano Quebrado, Gigante, and Gigantito will ever reach the canal. Those waters will be diverted. Here are those streams on the map.

(General Davis pointed out upon the map the streams referred to.)

Senator MORGAN. They are retained by dams that form lakes or—

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map]. The Trinidad does not come out into the canal at all; it discharges here [indicating]; it passes through the old Chagres Valley and goes through that diversion, which diversion is supposed to be crossed by the Gatun dam here [indicating], and so goes out to the sea here [indicating on map]. The Gatuncillo comes in here and takes the old French diversion channel, from which they excavated 2,500,000 cubic yards, and finds the sea here in Manzanilla Bay. That channel is open except in two short spaces; one is at Mindi and the other is opposite Monkey Hill. Those two obstructions remain, perhaps a half mile long in the aggregate, and have to be taken out. Then there will be a channel open from Gatun all the way to Manzanilla Bay 15 feet deep and 110 feet wide. Of course there is some dredging to be done.

Senator MORGAN. That channel is already dug?

General DAVIS. Except those two bulkheads.

Senator MORGAN. And paid for?

General DAVIS. And paid for. The remaining streams, some 22 in number, may possibly, a day or two at a time, at intervals of many years discharge over weirs from settling basins 29,000 second-feet of water. For three hundred days in the year those are mere brooks or are dry altogether and carry no considerable quantity of silt, for their beds are generally rocky and drain a densely vegetated terrane. It is impossible to conceive that the silt from all these little mountain brooks could exceed a half million yards annually. In other words, the annual expense for maintaining the channel depth as affected by silt from these little streams would not exceed \$150,000 a year.

Bearing upon that point I would like to mention what is a fact—that the Manchester Ship Canal, which is 36 miles long and parallels the river Mersey throughout its whole extent and impinges upon the river near Manchester, receives directly into its own prism a river called the Weaver, which drains the county of Cheshire to the south of Liverpool and Birkenhead. That one stream alone, which is as muddy a stream as I ever saw, full of silt, discharges in flood into the Manchester Canal 36,000 second-feet; it does it, it is doing it every year, and that water is taken in, and of course spilled out again over a weir into the Mersey. The river Mersey carries 58,000 second-feet. Those are facts that engineers have had to deal with and have solved. They are as well known as any facts in engineering. That river Weaver alone is a very large stream in time of flood, and very muddy indeed. When I saw it it looked to me as I have often seen the upper Missouri or the Rio Grande in Texas; it looked very much the same.

The entire expense of maintenance of the Suez, including the dredging referred to, reaches \$682,000 a year for 104 miles of canal, which is at the rate of \$6,560 per mile. Let it be assumed that an equal amount of work at Panama will cost \$10,000 a mile, and we have for the Panama Canal, say, \$500,000 per year for maintenance independent of the tide locks, only partially used, and sluices. For this purpose \$100,000 a year should suffice, or \$600,000 a year for maintenance of channel depths and water-regulation lock and sluice. But it is not claimed that for a few years after the canal is opened to traffic the dredging will be so little as above stated, for the waves made by the steamers will at first to some extent scour and erode the banks and margins. This, however, will be a constantly reducing

item. The banks can be revetted by being pitched, as engineers use the phrase, with rock laid loosely—not as solid masonry—as the Suez Canal has been throughout, perhaps, three-quarters of its length. They speak of it as pitching the banks, so that the waves made by the passing steamers, instead of striking back into that sand and carrying out a lot and spilling it out into the canal again, will expend their force against this rock revetment, which is made out of common loose rock.

Senator MORGAN. A good deal of the rock is manufactured on the ground, is it not?

General DAVIS. No; at Suez they have plenty of rock.

Senator MORGAN. They have plenty of rock?

General DAVIS. Yes; there are plenty of specimens here in the city. Mr. Quellennec had a lot sent here. Nearly all the rock is near the Red Sea south of Ismailia; it is quite hard, quite dense sandstone.

For the first ten years after the canal is put into commission the expense for transit should not exceed \$500,000 annually. The Commission and the minority say that the maintenance of turn-out places would be a considerable expense, but no definite figure is assigned. There are 23 turn-out places or sidings at Suez, 10 of them being equipped with telegraph as signal stations. The cost of all is found to be about \$60,000 annually. Allowing for seven such stations at Panama, as suggested by the minority, and for higher unit charges than at Suez, these turn-outs, about which so much has been said, might cost \$15,000 a year.

There is a further expense at Suez for buildings and their repair, wharves, storehouses, quarters for employees, telegraph and light keepers' residences, light-houses, and waterworks. This is a matter of considerable importance, as the expenses for water supply alone reaches \$170,000 annually on an average. The cities of Port Said, Ismailia, and Suez have to be supplied with water brought from the Nile, and it must be pumped to requisite elevations, permitting a head adequate for distribution. At Panama there is a surplus of water, and the cost of supplying the operating staff and steamers will be very small, for it will be a gravity supply. The total expense at Suez for buildings of all kinds and water supply reaches \$470,000 a year. At Panama it should not exceed \$250,000, for at the time the canal is opened to traffic there will be many times as many buildings available as there is any use for.

The general administrative expenses, including legal and financial, on the Isthmus of Suez reaches \$98,000 yearly. I am supposing that at Panama it will be about the same. At Suez they spend annually \$36,000 for sanitary service and hospitals. This cost at Panama should not exceed \$100,000. The Suez general offices in Paris cost annually for salaries of all kinds, legal advice, financial management, etc., the large sum of \$226,000, but it should be remembered that the Suez Company is a rich corporation, with some 40 members composing the board of directors, and all receive salaries or allowances that reach a large total. As the central office for the Panama Canal should be a branch or part of the general fiscal administration of our Government there should be no charge at all under this head.

The CHAIRMAN. Is Paris the headquarters of the Suez Canal?

General DAVIS. Yes; I was in the office a few months ago when I was there in Paris.

Summarizing these remarks respecting expenses, we have the following for a canal of sea level:

Maintenance of the canal channel, including dredging and maintenance of slopes.....	\$500,000
Maintenance and operation of one lock.....	100,000
Transit service of all kinds.....	500,000
Buildings of all kinds and water supply.....	250,000
General expense on the Isthmus.....	100,000
Sanitation and hospitals on the Isthmus.....	100,000
Total	1,550,000

The maintenance of channels for a lock canal would probably cost less than for one at sea level, but the transit and other services would be about the same, but the expense for maintaining and operating the locks would be very much greater. If this expense were in proportion to the total lockage, then the addition for locks would probably reach \$800,000, but if it should reach the sum of \$159,000 for the tide lock, as suggested as possible by the minority, then the corresponding item for their six locks, each with 8 feet greater average lift, would mount up to \$1,382,000 yearly.

Applying one of the minority methods of calculating lock charges, based on a percentage of their cost, the total of the sea-level maintenance would reach \$1,609,000 and the lock estimate would reach \$2,732,000 yearly, a difference of over a million dollars a year.

For the lock canal the estimate of expense of operation and maintenance by same method of computation would stand about as follows:

Maintenance of channels, including dredging.....	\$400,000
Maintenance and repair of locks.....	800,000
Transit service.....	500,000
Buildings of all kinds, including water supply.....	250,000
General expense on the Isthmus.....	100,000
Sanitation and quarantine on the Isthmus.....	100,000
Total	2,150,000

It will be observed that nothing is included for the government of the Canal Zone in either estimate, as this is considered as one of the general expenses of the government. Its cost over and above local revenues may reach \$100,000 a year after the canal is opened and will be the same for either type. It should not exceed this figure. The cost last year for Zone government, not including sanitation and hospitals, was—

Executive office	\$49,910
Judiciary	17,888
Attorneys' office.....	2,082
Police department.....	71,303
Total	141,183

After the construction work stops, the population diminishes, and the conditions become normal the Zone government will become a small item of expense.

The Secretary goes on to say that either type of canal is vulnerable, the higher level the more so.

Considerations of safety and protection, fixedness and stability should have weight almost paramount with the determination of type.

All agree that the ideal canal is a wide and deep passage navigable

at all times, day or night, at all seasons, and in all weathers by all sorts and sizes of vessels.

The underwriters now ask no increased premium for insurance of vessels and cargoes traversing the Suez Canal over those customarily paid on ordinary marine risks by same vessels navigating the oceans. I think that is a very important consideration, gentlemen. If there is anything certain with respect to underwriting and insurance it is that the property or the life must pay the risk.

If, carrying a policy in an insurance company, I go to the Tropics for a trip or to live there I have to pay an increased premium, because they consider it as an increased risk. If a vessel proposes to navigate dangerous seas, specially dangerous ones, where there are few light-houses and not much known about the hydrography, where there are uncharted rocks and that sort of thing, those vessels have to pay an increased premium. Now, here is this Suez Canal, asserted to be tortuous, dangerous, contracted. Should we not find an expression of that in the underwriters' risks? It seems to me as palpable as anything can be. But it is not there. There is no charge over and above the usual charge for vessels for general navigation for traversing the Suez Canal. I think there is no extra charge at the Soo; there is none at Manchester; there is none at the Kiel Canal. According to the underwriters, canal navigation is counted to be attended with the same risks—no greater, no less.

Senator KNOX. How do you undertake to say, if a vessel is insured from Liverpool to Calcutta, that the risk in passing through the Suez Canal is not taken into consideration in charging for the insurance?

General DAVIS. Because the underwriters' charge is the same—

Senator KNOX. You mean either by going around—

General DAVIS. By going around by the Cape of Good Hope or through the canal; yes.

Ships of all sizes up to 560 feet long, 78 feet beam, and 27 feet draft are now passing regularly and uninterruptedly between the Mediterranean and the Red seas, and please take notice always that there are but 15 commercial vessels in existence and but some 20 or 30 war vessels existing with greater dimensions than the largest which has already passed Suez, and they have passed Suez in seventeen and one-half hours—that is to say, at the rate of 10 kilometers an hour, or 6½ miles.

There are now but seven commercial vessels under the American flag, and no naval vessels, unless built within a year, that can not now easily make the 104 miles transit at Suez in a maximum of eighteen hours. Yet the minimum width is but 108 feet and the depth but 31 feet, and it has six curves of less radius than the smallest proposed by the majority of the Board, for Panama. When the widening and deepening now in progress at Suez are completed that canal will be twice as long, somewhat narrower, and much shallower than the proposed sea-level American canal which is realizable in ten or twelve years at a cost of \$250,000,000. It will afford convenient passage to the largest existing ship in a maximum of ten hours.

Can a canal possessing such characteristics of capacity, stability, and safety be justly compared with one whose very existence depends upon questionable earth dams, and these to permit the impounding of water to feed probably inadequate and actually obstructive locks

wherein the world's commerce and navies are to be lifted and lowered 170 feet, and all justified on the plea that the money cost will be a hundred millions or so less and the time of construction a very few years less than for the other which, for the present generation, will be a broad, open channel 150 to 200 feet wide, and for the next generation will be 300 feet wide, this increase to be attained at an added cost of perhaps \$50,000,000 to \$90,000,000?

We may well concede that if we could have a sea-level canal 300 or 400 feet wide it would be preferable, but the time and cost of constructing it are in effect prohibitory. The Secretary says this in effect and explains that it is the arguments of the minority, showing the results of the use of locks, the greater cost in time and money if these devices be excluded, and the dangers of the narrow and contracted canal prism that have caused him to change his opinion and to abandon the idea of the sea-level type as the best form.

It has been shown that the plans of the majority will insure to us a canal that is not dangerous, narrow, or contracted, for that remark does not apply to existing Suez, which is much longer, narrower, and shallower, and has more abrupt bends than the one proposed by the Board.

It is the opinion of very able engineers that the cost in time, which the Secretary puts before money, will be but slightly more for the channel at ocean level than for the one upheld 85 feet above the oceans by structures that have been pronounced to be questionable, vulnerable, and obstructive by many of the world's ablest engineers.

It is certain that the cost in money of the simple low-level channel, in which every existing and projected vessel would find convenient passage, will cost some tens of millions more than the complicated high-level structure, but the former will closely approach and ultimately result in the ideal, simple, natural waterway that the Secretary desires, while the latter will stand for the opposite until heroic measures are resorted to and the objectionable structures are removed, for the idea of transformability is eliminated by the minority.

They have said that if a sea-level canal is demanded let it be built at once; if the lock canal is built, let it be built to serve for a very long time.

Senator KITTREDGE. What have you in mind in the use of the words "heroic measures?"

General DAVIS. Cutting out these locks that will cost \$35,000,000, and putting them on the scrap heap.

Senator KITTREDGE. Would that involve delay or interference with traffic?

General DAVIS. Possibly not. I think it would be possible to do it without any great delay—possibly. That word, however, has a very far-reaching signification. I think the minority say somewhere—or some of the gentlemen of the minority say somewhere—about constructing a third lock while the other two are being enlarged or being changed. I think I have read that somewhere in the testimony.

The Spooner Act contemplates the use of borrowed money in meeting the cost of this great work, which is to serve the present and future generations. Our posterity will, as they should, redeem the obligations incurred, and they will be glad to do so if we show as the proceeds of the expenditure a monumental and complete work re-

quiring only moderate charges for maintenance, but if instead we should leave as the proceeds of our outlay, their inheritance, a structure that could only be transformed by its obliteration, then the financial aspect of the case to posterity would have a different meaning.

We now know and all agree that the best isthmian canal should have certain physical features. Nature has interposed no obstacles to their attainment which are insuperable if measured by the capacity of our engineers and contractors and national resources.

If the interest charge on the cost of the canal should reach six or seven millions and the tonnage and revenue should equal what Suez has, every canal bond could be redeemed in twenty-five years from the date of opening.

Can a programme that involves the making of this canal in ten or twelve years at a cost of \$250,000,000 be considered as justifying the observation that such conditions "are in effect prohibitory?"

Of course the Secretary, in saying that in substance, was speaking of a canal three or four hundred feet wide. I haven't any idea at all that that three or four hundred foot wide channel will be demanded at first. The canal will serve its purpose for many years with the dimensions proposed. It will enable our commercial vessels and our navies to pass and repass with perfect facility, a naval fleet of battle ships and cruisers half a mile apart can go through that canal in constant procession and average six or seven hours in the canal. Of course we will clear the canal for such a thing as that and have nothing to obstruct it. If we had at Panama to-day the present Suez Canal, you gentlemen would not be in session to-day or this Board of Engineers would not have been appointed. The American nation would be delighted to have even that channel—a channel 108 feet wide at its narrowest place.

Senator KNOX. What is the average width of the Suez Canal?

General DAVIS. Its minimum width is 108 feet and a fraction. The canal has been widened throughout a considerable part of its extent to 118 feet. The management is now at work enlarging it throughout its whole extent to make it nearly the same width as it now is in the turning out places. The width in those places is 147.6 feet. When all those turning out places shall be connected together, as they will be in a few years, then the canal will be 147.6 feet wide throughout, and it will be 31.4 feet deep. That is the ultimate depth to which they are looking at present. That will apply throughout the canal, except in two cases, and those are the two lakes. One is Timsah, where the canal, coming up from the Mediterranean enters the lake and then turns a right angle almost immediately on a curve with a radius of about 4,000 feet; it turns over 90° at that one spot, but the lake is deep, it is nearly deep enough to accommodate this proposed depth. They have dredged Lake Timsah, however, to get the full depth, and will have to dredge still more to get the 34 feet. That will not be difficult. There is a wide place—I suppose three or four thousand feet—and the next place is Bitter Lake, which is 9.38 miles long, and it has two changes of direction in it, but it is lake navigation. It has resulted from the filling up of this ancient basin by the salt water from the Mediterranean or Red Sea. I think that answers your question.

Senator KNOX. Yes; very fully.

General DAVIS. The approaches for the Suez entrance are wider. I have forgotten how much, but I think 500 feet. You might say they have two harbors——

Senator MORGAN. Are there any gates at either of the harbors?

General DAVIS. None at all; no, sir.

Senator MORGAN. The tide rises 7 feet, I believe.

General DAVIS. Between 7 and 8 feet.

Senator MORGAN. In the Mediterranean?

General DAVIS. No; in the Red Sea.

Senator MORGAN. How much in the Mediterranean?

General DAVIS. About 2 or 3 feet; something like the tide in Limon Bay. I arrived at Suez in the night, and at daylight in the morning there were half a dozen vessels anchored there ready to go on. A tug came along with a lighter and inquired whether we had an electric lighting apparatus on board. We had; it was a Government transport. They then took out of their lighter a square box 6 or 7 feet square and hoisted it to the bow and made it fast to the stem of the ship and about 5 or 6 feet above the water. In it was a man sitting on a stool. In front of him was a searchlight, and he was connected with the pilot on the bridge by signals. When our turn came we were given a number, and a large piece of canvas bearing the number in large black figures was hung over the ship on each side and we started into the canal, I should say about half a mile behind the ship ahead of us and half a mile behind us was another vessel, and in that way we went on through. The signals were made that we were coming. They knew our number at the telegraph stations. They could see it hanging over the side of the ship. Those big letters were 10 feet long. The manager, like a train dispatcher, directed that such a vessel come into a turning-out place and that ours could proceed, or that ours should go into a turning-out place and another vessel should pass, just as the case might be, and so they went on through, night and day.

Ninety-seven per cent of all the vessels traversing the Suez move just the same at night as in the daytime. There is no difference. They have such a system of electric lighting that there is no trouble. If a vessel comes without its own electric-light plant a little donkey engine is put on the deck, and that donkey engine moves a dynamo that supplies electricity, and when the ship gets to the end of the canal they take off the donkey engine and take off the dynamo, and the ship goes on her way. It is a perfectly simple thing.

Port Said, as you know, is a great coaling station. Almost every vessel takes coal there. At Suez, the Red Sea entrance, no coaling is done. And so with the Panama Canal, at Colon will be the coaling station. Panama will never be a coaling station. Coal is occasionally brought to Panama from Australia. Australia has a very good coal; indeed, much better than any Japanese coal, and much better than any of our own coal on the west coast. Some of the Australian coal rates pretty close to our Pocahontas coal—pretty near it. While I was at Panama there was a sailing vessel of 3,000 or 4,000 tons that came from Sidney with a cargo of coal for the Pacific Mail Steamship Company and lay there until her cargo was taken out by lighter, and then she went on her way.

INCREASING SIZE OF SHIPS.

A study of the Suez statistics throws much light upon this subject, for the average size of the vessels using this—the largest and most important maritime waterway in the world—is constantly growing, as may be seen from the following tabulation derived from Senate Document 20, Fifty-eighth Congress, first session:

Year.	Number of vessels.	Gross tonnage.	Net tonnage.	Mean net tonnage per vessel.	Per cent increase, 5-year periods.
1870.....	486	654,915	436,609	898	.....
1875.....	1,194	2,940,708	2,009,984	1,345	44.8
1880.....	2,026	4,844,519	3,057,421	1,509	11.5
1885.....	3,624	8,985,411	6,385,752	1,748	15.8
1890.....	3,889	9,749,129	6,890,094	2,038	16.3
1895.....	3,434	11,838,637	8,448,383	2,460	18.3
1900.....	3,441	13,699,237	9,738,152	2,880	17.9
1905.....	4,116	18,000,000	13,000,000	3,149	11.3

If increase in size of ships navigating this canal continues to augment at the same rate as for the last ten years, which is 28 per cent, then the average of Suez vessels in 1915 will be 4,225 tons, and for 1925 will be 5,524 tons.

But these statistics show something more, which is the increasing use of the canal by large ships.

In 1890 the number of vessels passing drawing more than 24.6 feet was 145, while in 1895 there were 228, or an increase in five years of 57 per cent. Again, in the same period the number passing in 1890 of over 25.3 feet draft was 44, while five years later it was 85, showing a gain of over 93 per cent in the size of the users. We thus see that the draft, and therefore the tonnage of the 24.6-foot vessels plying the Suez route, is increasing more than three times faster and the 25.3 vessels over five times faster than the average augmentation.

The reason why the Suez management are continually increasing the transit capacity of this waterway is thus made very manifest. These shrewd business men see plainly that their canal will become a second-class route unless it is enlarged. It requires no prophetic vision to see that the Suez Canal by 1950 will have a channel 40 feet deep, 300 feet wide, and with curves flattened to minimum radii of 10,000 feet, and can we doubt that Panama will have the same or greater dimensions? With equal prism and curvature, it will be much more convenient, because only half as long.

Now, as respects the financial side of Suez, and as concerns these figures of estimates, cost and maintenance. I would say that the data I have is derived from certain telegrams or from a certain telegraphic correspondence which was had in the month of March, the present month, with Mr. Quellenec, who was a member of this Board of Consulting Engineers, and who is the chief engineer of the Suez Canal. The telegraphic correspondence was conducted by Mr. Shonts, the chairman of the Commission, at my suggestion, and the answers are all sent to Mr. Shonts, and I have the originals in my hand. It is perhaps not necessary to read them all now, because I have tabulated what they say in a paper here which has been used by myself in preparing the arguments I have laid before you respecting maintenance. There is one item that has been referred to there, and which is a very

important one, as applying to the whole problem of the Panama Canal or any other interoceanic canal.

The CHAIRMAN. Are those telegrams long?

General DAVIS. Not very long.

The CHAIRMAN. Then they might go in the record.

General DAVIS. I will be glad to insert them.

The CHAIRMAN. There is no objection to it?

General DAVIS. No, sir. They were sent at my request by Mr. Shonts, who very courteously attended to the correspondence for me, and they have been sent to me, and I see no reason why they should not be printed as part of the record.

The telegrams referred to are as follows:

[Cablegram.]

ISTHMIAN CANAL AFFAIRS,
OFFICE OF ADMINISTRATION,
Washington, D. C., March 6, 1906.

QUELLENNEC,
Suez Canal, Paris:

General Davis would be greatly obliged for telegraphic information respecting Suez. Average costs last three years: First, permanent improvements, like widening, deepening, etc.; second, maintenance and operation, including repairs, renewals, dredging (total cubic meters); third, separate figures of cost, maintenance, and operation of all turn-outs, including services, equipment, repairs, giving number of turn-outs. Please reply collect.

SHONTS.

[Cablegram.]

PARIS, March 9—8. 57 a. m.

SHONTS, *Washington:*

Average annual expenses Suez Canal last three years: First, permanent improvements, 3,836,000 francs, including repairs; 2,620,000 cubic meters excavated in dry or by dredging. Second, maintenance, 3,410,000 francs, including repairs; 2,610,000 cubic meters dry and dredging operation, 3,117,000 francs, including repairs; renewals, 1,500,000 francs; buildings and waterworks maintenance and operation, including repairs, 850,000 francs. Please explain exact meaning of word "turn-outs."

QUELLENNEC.

[Cablegram.]

ISTHMIAN CANAL AFFAIRS,
OFFICE OF ADMINISTRATION,
Washington, D. C., March 9, 1906.

QUELLENNEC,
Suez Canal, Paris:

General Davis requests I wire you as follows:

"Turn-outs" mean sidings. Information Davis desires to answer criticisms that cost maintenance of siding for sea-level canal would

be large item. Your answer understood to mean that all permanent improvements, including excavations, cost three million eight hundred thirty-six thousand francs, and all maintenance, including dredging, etc., repairs, renewals, buildings, waterworks, and their operation reached total of eight million seven hundred seventy-seven thousand francs. How much, if any, part this last amount should be charged to permanent improvements?

SHONTS..

[Cablegram.]

PARIS, *March 13—9.10 a. m.*

SHONTS, *Washington:*

No particular expense of maintenance operation for turn-outs other than those respecting signal and telegraph stations with which ten turn-outs out of twenty-three are provided by such stations, operation of which costs annually about three hundred thousand francs, would be necessary even if there were no turn-outs. Turn-outs are no cause of expense neither for company nor for ships. Mooring of ships to let others pass entails but a delay of one hour and half on the whole time of passage of seventeen hours. Three million eight hundred thirty-six thousand francs is total cost of permanent improvements, including all kind of works, especially dredging in soft and rocky material, repairs, etc.; also engineering employees, etc. Eight million eight hundred seventy-seven thousand francs is total cost of maintenance and operation; namely, first, five million seven hundred sixty thousand francs for maintenance, including all kind of works, especially dredging, repairs, renewals, buildings, waterworks, and their operations, also engineering employees, etc.; second, three million one hundred seventeen thousand francs for operations of canal. In other words, for transit of ships, including pilots, telegraph, signals, launches, tugs, operations, and repairs of the same, measurement of ships, also marine officials, employees, etc. Besides these expenses there are, moreover, general expenses as follows: In Egypt, for representative of company, financial service, legal department, etc., four hundred ninety thousand francs, and for sanitary service one hundred eighty-eight thousand francs; at Paris, for direction financial service, legal and accounting department, one million one hundred thirty-four thousand francs. No part of cost of maintenance to be charged to permanent improvements, discrimination being already made in accounts.

QUELLENNEC.

[Telegram.]

ISTHMIAN CANAL AFFAIRS,
OFFICE OF ADMINISTRATION,
Washington, D. C., March 15, 1906.

QUELLENNEC, *Suez Canal, Paris:*

Cable names, dimensions, draft, three largest vessels passing Suez since nineteen four. Do largest ships move at night, and their average time transit? What was total number vessels with gross and net tonnage passing nineteen five.

SHONTS.

[Cablegram.]

PARIS, March 17—9.07 a. m.

SHORTS, Washington:

Grosser Kurfurst, 560 feet long, 62 broad, 26 feet 3 inches draft. *Good Hope*, 520 long, 78 broad, 26 feet 3. *Terrible*, 539 long, 72 broad, 26 feet 3. Largest vessels can move at night, their average time transit almost same as average transit all vessels, which was 17 hours 41 minutes in 1905. Total number vessels passed, 4,116; gross 18 million tons, net 13 millions.

QUELLENNEC.

I have a memorandum here, "Suez Canal, cost of enlargements, maintenance, and operation, average per annum for last three years—1903, 1904, and 1905."

Permanent improvements, which have been going on almost ever since the canal was opened, during these three years are described as respects their cost by this remark: Consisting of widening, deepening, and so forth, which includes 2,620,000 cubic meters—equal to 3,426,960 cubic yards—of excavations in earth and rock, excavations by dredges and other methods, including excavation of rock under water, engineering labor, and so forth; total expenditure per annum, 3,836,000 francs, equaling \$767,000.

Senator DRYDEN. That is not charged to the cost of the canal?

General DAVIS. No; although it is in our railroad parlance a betterment, and is a legitimate charge against the property, for of course the property is worth that much more. But here, instead of floating bonds and raising that much money on loans, for this work they take it out of their earnings, and that amount for the last three years was \$767,000 annually. That will be completed some day and then it will be a question of whether still further enlargements may not be necessary; but so far as we now know their programme only consists of connecting up these existing passing places and deepening the canal to 34.4 feet.

The next item is maintenance and operation, which includes dredging to maintain channel, amounting to 2,610,000 cubic meters, or 3,413,880 cubic yards. Also renewals, repairs, buildings, waterworks with their operation; also engineering employees, as follows:

Dredging, repairs and renewals, 3,410,000 francs, or \$682,000. Buildings and their repairs, including waterworks and maintenance, 2,350,000 francs, or \$470,000. Transit, which includes pilots, telegraph, telephone, lighting, launches, tugs, operation and repairs, measurement of ships, marine officials, 3,117,000 francs, or \$623,000. General expenses, including representatives near Egyptian Government, financial service, legal department in Egypt, 490,000 francs, or \$98,000. Sanitary service, 180,000 francs, or \$36,000. Expenses in Paris, financial, legal, and accounting, 1,134,000 francs, or \$226,800. For all expenses connected with betterments and maintenance and operation, administration, and so forth—

Senator MORGAN. Since the canal was first opened?

General DAVIS. No; the average for the last three years. The

total transit receipts for 1903—that is the last year for which I have any figures—were \$20,121,680.

Now, deduct all expenses as above, \$2,902,800, leaving a net total of \$17,218,880.

Now, the dividend paid last year on the Suez shares was 125 francs on a 500-franc share. That is, it was 25 per cent of the original capital invested. The canal pays for itself every four years. The 500-franc shares are now selling for 4,000 francs.

Senator KNOX. What is the capital now?

General DAVIS. The original capital was 400,000 shares at 500 francs.

Senator KNOX. What is the capital now?

General DAVIS. The original was 400,000 shares at 500 francs—that is, it was 40,000,000 dollars.

Senator KNOX. Is that the capital now?

General DAVIS. That has been increased. In the earlier years the enterprise had to struggle for existence; it had a lot of enemies, one of the strongest being the Government of Great Britain; they put every obstacle in the way, and that continued; it did not pay expenses at first. But pretty soon they saw it was going to be a winner, and then Disraeli, who was a wise man, looking ahead, without authority from Parliament, without authority from anybody, went in and bought out the Khedive's interest in the canal, which was 162,600 shares of that stock, which had been originally assigned to the Khedive. They paid a little less than £4,000,000 for those shares. Those shares to-day are worth £25,000,000, and can be sold for that at any time. When they had their troubles in the beginning and the rates were high, 10 francs a ton and 10 francs on a passenger, the shippers resisted those charges and made claim to the Government of England, represented what a tax this was imposed upon shipping, how the canal could be duplicated for \$40,000,000, and then they brought out a project to make a lock canal from Alexandria to Cairo and from there to the Red Sea. They proposed to lock up 20 or 30 or 40 feet. I have forgotten how much. That enterprise was agitated a good deal and it alarmed the Suez people.

A conference was had between the owners of the Suez Canal and the shippers, the English shippers principally, as to whether it could establish some kind of a compromise, which they did. It was then agreed that when the canal's shares should pay a certain dividend, which it looked as if they were going to pay then, because the trend was upward, after that a certain proportion of this dividend should be divided between the investors, that is, the property owners, and the shippers, and under that agreement the tolls have been reduced. The first reduction was to 9 francs, from 10 francs; the second reduction was to 8.5 francs, and then they were reduced to 8 francs. And it was provided in this convention that when the shares should pay 25 per cent dividend then the rate of division of this profit should be still larger in favor of the shippers. So that on the 1st of January last the tonnage charge on the Suez transit was 7.75 francs. Whether that applies to the passenger charge or not I don't know. I did not ask the question and did not find out, but they are cutting down the tonnage charge regularly and still they are paying for the canal every four years.

Senator DRYDEN. Did the Khedive pay anything for his shares?

General DAVIS. Oh, yes; he put up money for them.

Senator DRYDEN. The same as the others?

General DAVIS. Yes.

Senator ANKENY. Referring to these extensions and betterments on the Suez Canal, that you speak of, was there any suspension or delay of traffic while that was going on?

General DAVIS. Never for an hour.

Senator ANKENY. And might not a sea-level canal at Panama be widened, if the necessity ever arose, without disturbing traffic at all?

General DAVIS. Yes; just as certainly.

Senator MORGAN. There was a time during the siege of Alexandria when Great Britain stopped traffic through the Suez Canal.

General DAVIS. Oh, yes.

Senator MORGAN. Although Great Britain was a minority stockholder.

General DAVIS. Oh, yes; that was done. There has not been a day since the Suez Canal was opened that something has not been done to improve it—that is, improvement has been going on all the time.

Senator ANKENY. I mean these extensions or modifications of the curvatures, or whatever you call it, goes on without disturbance of traffic?

General DAVIS. Yes; without any disturbance. I think I saw six or seven dredges at work when I came through the canal, and that goes on all the time.

Senator ANKENY. In your estimates there of those cubic yards, what difference do you make between dry work and the wet work? The point I want to make is, Will not this wet work cost a great deal more money than we are prepared for?

General DAVIS. I am glad you asked that question, and I think I can give you some light on it. The Board of Engineers, considering that matter as applied to Panama and especially as applied to the sea-level proposition, agreed—the whole Board agreed to this—that these unit prices were, aggregated, 80 cents.

Senator ANKENY. Otherwise the work was below water?

General DAVIS. Yes. I was going to explain. Eighty cents for the above work plus 10, and \$1.25 below plus 10. The difference between 80 and 125, or 45, is supposed to be required for three purposes, and those three are the following: Water will get into these deep pits in the Culebra; evidently it will. It will come in from the sky; it will come in by trickling down the banks; it will not probably come in from below up, because, so far as we have discovered in the Culebra to-day with all our boring, we do not find any flowing water from the bottom; we do not find that there are any flowing springs in the bottom of the Culebra, and the only water that comes in there is the water trickling down from the banks.

Senator ANKENY. Practically surface water?

General DAVIS. Yes; seeping out of this soft material on the top and falling down into the canal; and then when they have a very big rain that water runs off the slopes and that runs into the canal. It was considered that pumps would be necessary to take that water out—a very simple proposition, for there is nothing cheaper than pumping water with those great centrifugal pumps, pumping out a 2-foot

stream, or, as Mr. Wallace said, he could pump the whole low water flow of the Chagres out of the bed at small expense if he wanted to. That is one of the items included in this addition of 45 to the 80 cents. Another is that you must haul that material uphill; that is to say, it has got to be deposited on levels higher than where it came from.

Senator ANKENY. It is mostly rock?

General DAVIS. Yes; but it has got to go upgrade; it has to go up those 40 feet. Those are two reasons why that 45 was added. The third reason is because when you get down into this narrow channel your space is contracted and you haven't room to straighten as you would higher up. So those are the three reasons for a higher cost below + 10. They added 45 cents to the estimated cost of the work above. There is an explanation, I think, which may answer your question.

Senator ANKENY. It is very clear, sir.

General DAVIS. With respect to this statement which I read, there is only one other thing to which I wish to call attention for which authority is found in these telegrams. The company states that maintenance of turn-outs or sidings, of which there are 23—ten provided with telegraphic service—costs nothing additional, as the service would be required if there were no sidings, but actual expense for sidings is about \$60,000, which is included in cost of transit as above, and that is the figure which I use deducted from this experience that the seven sidings at Panama would cost \$15,000 a year. The important statement is also made that the whole time of detention in sidings due to the mooring of ships entails a total delay of one hour and a half on the whole time of passage, which averaged seventeen hours forty-one minutes per vessel in 1905. Largest vessels proceed at night and make same average time as other vessels. That is the official statement. Now, as respects some of the ships that have passed through the Suez Canal. I could make a very long list, but a short one will serve every purpose. Here are some data.

In 1894 the *Grosser Kurfurst*, 560.5 feet in length, with a beam of 62.33 feet and a draft of 26.18 feet and a tonnage of 13,000 gross tons, passed through that canal for the first time, and since then has been through it a half a dozen times.

Senator KITTREDGE. What time did she make in going through?

General DAVIS. The same as smaller vessels, I understand. The statement is that the large vessels go through just as readily as the small ones. This is what this official says:

"Largest vessels proceed at night and make same average time as other vessels."

I can not answer specifically as to this particular vessel, but she is on the regular trade—on the North German Lloyds Line to China—and she has been going through regularly.

Senator ANKENY. One hundred and five miles in seventeen hours?

General DAVIS. Yes; that is the average time for 1905.

The CHAIRMAN. Is that the largest ship that has passed through?

General DAVIS. No; there are several larger that have passed through. In 1904 the British ship *Terrible*, length 500 feet, beam 71 feet, draft 26.24 feet, tonnage 14,440 tons' displacement, a British armored cruiser, passed through the canal in the regular time. In 1902 the *Mikasa*, Japanese battle ship, which went through the Japa-

nese-Russian war and was finally sunk, 432 feet in length, 76 feet beam, 26.24 feet draft, and displacement of 15,200 tons. She was built at the Cramp shipyard, and on going out to be delivered passed out through Suez.

In 1902 the North German Lloyd ship *Barbarossa*, 526.24 feet in length, 60 feet beam, 25.59 feet draft, and 10,915 gross tons, passed through the canal, and has passed frequently since then. She is running in the North German Lloyd China service.

In 1904 the British protected cruiser *Victorious*, 390 feet in length, 75 feet beam, 25.59 feet draft, and 14,900 tons displacement, passed through the canal.

Senator ANKENY. Is that the one that collided with the *Camperdown*?

General DAVIS. No; I think that was the *Victoria* or the *Victory*. She was sunk.

Senator ANKENY. I was only getting the size in my mind.

General DAVIS. I think that is another boat, the *Victoria*. In 1905 the British armored cruiser *Good Hope*, 530 feet in length, 78 feet beam, 26.25 feet draft passed through the canal. In 1900 the American battle ship *Kentucky*, 376 feet long, 72½ feet beam, and 26 feet draft, also the British battle ship *Glory*, 418 feet long, 74 feet beam, and 26 feet draft, both passed. There are eight ships. I suppose I could extend that to 50, but that is enough to show that here these ships can pass and that the canal is adapted to vessels of that size. There is not a single American war vessel, unless she has been put in commission this year, that can not go through the Suez Canal to-day, not a single one, and there are only six vessels under the American flag that can not go through. They are the *Mongolia*, the *Manchuria*, the *Minnesota*, the *Dakota*, the *Kroonland*, the *Finland*. They have a little more length than any ship that has gone through Suez.

Senator KNOX. What point is this data intended to establish?

General DAVIS. The fact that this canal proposed by this Board, which is much longer than Suez, is not tortuous and dangerous and inconvenient; that is the purpose.

Senator KNOX. I didn't have the advantage of hearing you this morning.

General DAVIS. I am sorry you did not.

Senator KNOX. So am I, very sorry.

General DAVIS. I am reviewing, at the request of Secretary Taft, his letter transmitting this report. He asked me to say to you all that he would be glad to have me feel perfectly free. This sketch shows the shortest, steepest, most abrupt curve in the sea-level plan.

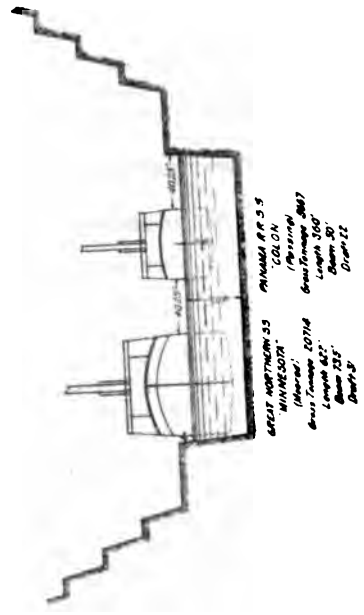
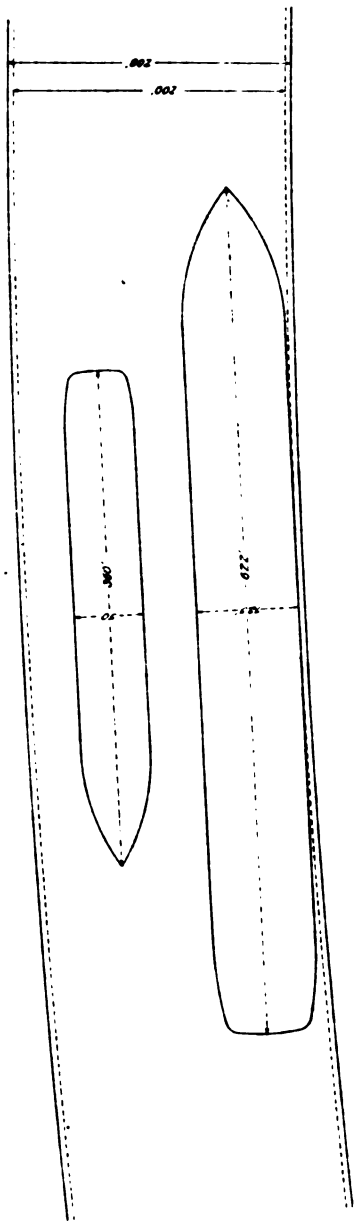
Senator KNOX. On what scale is that?

General DAVIS. One twelve-hundredth. That is a proportion scale. That doesn't mean very much, but that width of channel is 200 feet. It so happens that the four curves of 8,200 feet radius are all in that part of the canal which has a 200-foot bottom width. This represents the 200-foot bottom-width curve.

Senator MORGAN. What part of the canal?

General DAVIS. Somewhere near Obispo—yes; that one is right at Obispo [indicating]. That shows a ship in that canal 622 feet long, and that is drawn in plan on the same scale, and passing that ship you will see the lines of a smaller vessel, 360 feet long. It has been

MINIMUM CURVE
 PANAMA SEA LEVEL CANAL
 RADIUS 8202 FT.
 SHIPS MEETING



said that these curves are too abrupt, too sharp, that they can not make the turn. I want to say something about that. A few years ago there met in the United States what is called the Deep Waterways Commission, which was appointed by our Government. Mr. Noble was one of the engineers that sat on that commission. They discussed a great many questions about depth of channels and locks and curves and prisms and so forth, and they laid down a general proposition that curves for a canal, if they were of 10,000 feet radius and of due proportion of width, would be satisfactory—that is, a curve of 10,000 feet radius was just as practicable as a straight canal; they didn't propose any widening for any curve that had a radius of more than 10,000 feet; but for curves of less than 10,000 feet radius they proposed to widen the canal at the bottom and at the top; they proposed to widen the curve if it had less than 10,000 feet radius, according to the formula, normal width $\div (60 - .005 \text{ radius} = \text{curve width})$.

Senator MORGAN. You mean widen the canal?

General DAVIS. Yes; and in any particular curve. They laid down a formula for that calculation, and it is similar in character to the formula that Tinceauzer gives and the principles on which the curve widths for the Kiel Canal are computed.

Senator MORGAN. Was he a member of the consulting board?

General DAVIS. Yes; he says in the curve with a radius of 1,000 to 2,500 meters an increase of breadth of bottom is made by the formula

width, $+ 26 - \frac{R}{100}$ and therefore a curve of 1,000 meters must have an increase of breadth of bottom of 52.5 feet, and a curve of 2,500 meters must have an increase of breadth of bottom of 3.2 feet. In other words, when you get to 8,000 feet you have got a curve that so nearly approaches a straight line that the Germans who have studied this matter think that an increase of bottom width in those larger curves is unnecessary. The Suez people propose that a curve shall be of such an arc that when a ship is navigating it and her axis is on the center axis of the curve she shall have in front of her one and a half times her own length before the continued line would impinge against the banks. This curve is constructed on that basis for a ship 788 feet long. That curve satisfied the requirements of the Suez engineers who have studied that matter of corrections. That is to say, an 8,200-foot curve will give in front of that ship, before the prolongation of line of center axis will strike the bank, just about one and a half times her own length.

Senator MORGAN. That is considered to be enough?

General DAVIS. That is considered to be enough by, I think, all the world. The Deep Waterways people say when they have 10,000 feet, they don't concern themselves with its increase; a curve with a 10,000-foot radius, I mean, is so closely approaching a straight line that it can be treated as a straight line.

Now, there is certain physical data in regard to certain canals which I have compiled that is interesting, and I will call attention to a few phases of it and will leave this with you to be put in the record. This is existing and proposed canals.

General Davis read the following table, explaining it to the committee:

Existing and proposed canals.

	Units.	Panama, proposed sea level.	Kiel now.	Suez now.	Suez in future. ^a	Panama, lock.
Total length	Miles ...	49.35	^b 57.89	^b 94.76	94.76	49.72
Straight portion	do	30.18	^c 34.23	81.73	81.73	42.25
Curved portion	do	19.17	^c 23.66	13.03	13.03	7.46
Per cent in curves	Percent	38.8	40.9	13.4	13.04	15.00
Depth	Feet	40	29.52	31.2	34.4	^d 40
Least bottom width	do	150	72.17	108.25	147.63	^e 45
Least width in curves	do	150	75.2	131	^f 160	200
Least area cross section	Square feet.	8,160	4,444	^g 5,813	7,741	^h 250
Total curvature	Degrees	597	^c 832	467½	467½	637½
Curves	Number	19	26	15	15	24
These classified in radii:						
Over 14,000 feet	do	0	7	3	3	0
14,000 to 12,000 feet	do	2	0	0	0	0
12,000 to 10,000 feet	do	1	0	1	1	0
10,000 to 9,000 feet	do	12	10	2	4	0
9,000 to 8,000 feet	do	4	2	3	6	1
8,000 to 7,000 feet	do	0	0	3	0	0
7,000 to 6,000 feet	do	0	1	2	0	0
6,000 to 5,000 feet	do	0	1	0	0	7
5,000 to 4,000 feet	do	0	1	ⁱ 1	1	3
4,000 to 3,000 feet	do	0	1	0	0	6
2,000 feet and less	do	0	0	0	0	7
Locks*	do	1	2	0	0	6
Locks, length usable	Feet ..	1,000	492	0	0	900
Locks, width usable	do	100	82	0	0	90

^a Enlargements at Suez will not be completed for several years.

^b Total length Suez 104.8 statute miles, of which 9.38 miles in lake; excavated channel, 94.76 miles.

^c Data respecting total curvature and curved mileage not given in authority consulted, but are estimated above at the average of Suez and Panama.

^d On lock sills.

^e Prisms.

^f About.

^g Least width future Suez curves, approximate.

^h Approximate.

Total length Kiel 60.89 statute miles, of which 3 miles in lake; excavated channel, 57.89 miles.

ⁱ Area cross section 5,813 square feet at low water and 6,025 square feet at high water.

^j This curve has only 4,266 feet radius, but its bottom width is 1,640 feet.

* Tide lock maximum lift, 10½ feet. Will be in use only a part of the time.

Panama lock plan proposes lengths and bottom widths as follows:

Widths (feet).	Lengths (miles).
1,000	19.08
800	8.86
500	12.29
300	7.21
200	4.70
Locks, etc	2.68

Senator MORGAN. You have omitted entirely the canal at Nicaragua, which was reported three times by the same commission that reported in favor of the Panama lock canal.

Senator DRYDEN. That has not been built yet, has it?

Senator MORGAN. The Nicaragua Canal?

Senator DRYDEN. Yes.

Senator MORGAN. Nature has done more toward the building of it already than toward the building of the Panama Canal, and more than it ever will do toward the building of the Panama Canal.

But will you not please take that report of the Isthmian Canal Commission, called the Walker Commission, which report was made, you remember, three times, twice to the President and then again as alternative proposition to the lock canal at Panama—made three times by some commission—will you not take that and put the same data with reference to that canal upon this table that you have made out?

General DAVIS. I perhaps might not be able to do it to-night, because when I get home it will be dark; but I can do it in a day or two and add it, if that will answer.

Senator MORGAN. Yes; I would be very much obliged to you. I just want to preserve the history of the situation as we go along.

General DAVIS. There are only a few points more.

Senator ANKENY. What effect does the wind have upon the sea-level canal when vessels pass in there?

General DAVIS. Well, that is a question that will be hard to answer.

Senator ANKENY. You mention that the Germans at Kiel had to change their canal on account of the North Sea wind.

General DAVIS. No, on account of the effect of the wind on the tide, not on account of the wind on the ship; but the effect of the wind in backing up the water. You know the wind has a decided effect in backing up water.

Senator ANKENY. Yes.

General DAVIS. That is what I mean by that.

Senator ANKENY. We haven't considered that at all in any of this?

General DAVIS. No.

Senator ANKENY. Is it of no consequence?

General DAVIS. I would not say it is of no consequence. I think it is of some consequence. I think it is of consequence to any canal which is built.

Senator ANKENY. How about the effect if we had a flight of locks, three, for instance?

General DAVIS. I think it would have an effect, but it would not be serious for a lock system. They have no difficulty of entering the ships at the Soo lock in all kinds of weather, and I think they would do the same in a lock canal down here.

Senator ANKENY. You think that is not a factor in the business?

General DAVIS. I do not think it is, sir; I do not think it is a serious factor. I know the navigation goes on all the time at the Soo and they have at times a good deal of wind there. In some of the reports I have read about Suez, they discussed the winds at considerable length, and I have never heard—and I have read a good deal about it—that the winds interfere with navigation at Suez. I know they do not interfere with it at Kiel or Manchester. The Corinth Canal carries its shipping through that narrow gauge and they have no trouble there. I do not think the wind is anything serious to consider. Panama is generally, fortunately, free from winds; that is, free from violent winds; they have the trade winds.

There is one other matter which comes up in respect to the requirements of the lock canal for lockage water—water for lockage purposes. I made these notes to illustrate something in that line. Capacity of Gamboa and Gatun lakes to supply water for lockage

purposes. Summit level, 85 feet, or supposed to be that, in each case. I know there has been no plan prepared for a lock canal with a summit at 85 feet that contemplates the use of the Gamboa water, but this study supposes Gamboa Lake to be raised to 170 feet above the sea. If so, it would contain 39,175,000,000 cubic feet of water. When I say that I mean that that drainage basin has been surveyed just as accurately as any piece of land that any of you gentlemen own. It has been traversed in every twist and turn by the topographers, and they know just where the water level will go for each foot of that reservoir area.

Senator MORGAN. That is called "Gamboa Lake?"

General DAVIS. That is called the "Gamboa Lake." Estimates have been made by engineers assigned to this duty by Mr. Wallace, and their reports show the contents of that reservoir for every foot of elevation up to 200 feet. When I say that the Gamboa Lake would contain 39,000,000,000 cubic feet of water raised to 170 feet above sea, I base my statement on the report of these gentlemen, who have put that particular figure down against 170 as the cubical contents of that reservoir. I think no one will dispute the accuracy of those figures.

Now, suppose you wish to supply a lock canal from that reservoir and that the summit level was 85 feet. I am supposing that the reservoir would not be drawn down below 90 feet—that is, that there would be always 5 feet margin. So I am supposing that this same Gamboa Lake will never go below 90. The net quantity that would remain in that reservoir between 90 and 170 is 36,580,000,000 cubic feet. There is a certain low-water flow that is going on all the time, and I am supposing that the low water continues for three months. General Abbot, who has spent more time in calculations in regard to the hydrography of the Isthmus than anybody else, and whose work is of great merit, has stated, I think from thirteen years' observation, that the low-water flow during the three dry-season months falls down to 1,176 second-feet, or 9,145,000,000 cubic feet. That is coming in all the time, and adding that to the other figure, we get a total, then, as available of 45,725,000,000 cubic feet. But there are certain wastages and leakages by evaporation and percolation, and those are estimated at 748 second-feet, which deducted leaves a net available amount of 39,909,000,000 cubic feet of water.

The minority state that the level of the Gatun Lake is expected to fluctuate, the maximum level at the beginning of the dry season standing at 86 feet and falling at the end of that season to 82 feet, the fluctuation amounting to 4 feet.

The waters contained between the two levels, as stated above, plus the increment, due to the low-water flows of the river minus the losses by evaporation, leakage, infiltration, waste, and use for power purposes, as computed from the data given by the minority, page 75, is 10,498,000,000 cubic feet, which quantity is stated by them to be sufficient for 26 lockages per day for three months.

If the lock canal were so constructed as to obtain its water supply from the proposed Gamboa reservoir the water would be sufficient for 98 lockages per day for three months, so sufficing for a tonnage 3.7 times greater, and this without building the Alhajuela dam, as contemplated by the minority, as an ultimate proposition.

Simply as a question of storage, now, and as having nothing to do with locks, I have here some figures as to the storage capacity of Gamboa Lake. The two parts of the Board, the minority and the majority, treat the Chagres River from two standpoints, separate and distinct. The majority treat the Chagres River as a nuisance to be gotten rid of the best way we can. The minority treat it as entirely essential to their plan to supply water for lockage. If they could not have that river to supply the water, they would be in a bad way. If we did not have the river for the sea-level purposes, we would be in a very pleasant frame of mind. But it is there and it has got to be controlled.

Now, these figures are to show to what extent the devices of the majority will affect its control.

The capacity, computed from actual survey of the lake between level 80 and 170 feet above sea level is, in round numbers, 38,000,000,000 cubic feet. The mean or average gauged flow of the Chagres River at Gamboa, as determined by General Abbot, is 3,164 cubic feet per second. That total flow for one year would therefore be, in cubic feet, 365 by 24 by 60 by 60 by 3,164, or 99,779,904,000 cubic feet. The lake would therefore contain nearly one-third the entire year's flow, floods excluded, without any discharge.

The greatest flood in the Chagres that has been heard of in fifty years was the one in 1879, when the water rose about 36 feet at Gamboa at its maximum, remaining at the level for a very short time. General Abbot computes this flood as sending out an average of 65,250 cubic feet per second for a period of forty-eight hours. This quantity is 48 by 60 by 60 by 65,250, or 11,275,100,000 cubic feet. If meanwhile there had been discharging through the regulating works 15,000 cubic feet per second, the total for forty-eight hours would be 48 by 60 by 60 by 15,000, or 2,592,000,000 cubic feet and the part of the flood stored would be 8,683,100,000 cubic feet.

Supposing the level of the reservoir to be standing at 80 when the flood began, the flood would raise the water in the lake to about +119 above sea, and there would still be a remaining capacity for more than four more floods of the same volume before reaching 170. But supposing there was no discharge through the regulating works while the flood continued and the whole should be drawn off at the rate of 15,000 second-feet (which, be it remembered, includes 3,164 second-feet representing the mean flow), and it would only take about ten days to spill this phenomenal flood.

It should not be forgotten that we have very complete data for the flow of the Chagres at Gamboa more than for any other station on the Isthmus. The data of actual gaugings available to the computer covered all the years from 1890 to 1904, both inclusive, and for every month of the one hundred and eighty save nine.

It may be deduced from the above that a dam with crest at 160 and water level at 150 might be adequate to meet the necessities of the case. Its storage capacity, between 80 and 150, would be nearly 24,000,000 cubic feet, or double the storage necessary to store two maximum floods.

Those are the principal matters, gentlemen, that I had prepared myself on. I have covered a good deal of ground, perhaps, or I have tried to.

Senator MORGAN. I suppose we have now gotten through with the main discussion—

Senator KITTREDGE. I should think this would be a good point to adjourn.

Senator MORGAN. I would suggest that if General Davis is through with his statement I would like to ask him one preliminary question, turning his attention to the government of the canal.

Is there any canal zone at Suez?

General DAVIS. Yes; there is a canal zone from the franchise which the Khedive gave to De Lesseps.

Senator MORGAN. What is the width?

General DAVIS. Very irregular in width. I could not tell you its width or shape, but in some places the area over which the Suez Company has fiscal control—they have no judicial control anywhere—

Senator MORGAN. That is what I wanted to get at.

General DAVIS. No; they have not.

Senator MORGAN. And they have no military control?

General DAVIS. No.

Senator MORGAN. And have no other control except such as is furnished by the laws of Egypt?

General DAVIS. Yes; that is all.

Senator MORGAN. That is all I wanted to get at as a preliminary. I wanted to ask you whether the area of the country through which this canal runs is at all populated.

General DAVIS. There are three cities—Port Said, with fifty or sixty thousand; Ismailia, with about 8,000, and the so-called "city of Suez," on the Red Sea, with three or four thousand inhabitants. There are no other inhabitants along the line of the canal; it is a desert. The water is brought from the Nile to supply these cities and also to supply a few gardens and a few little parks in those towns.

Senator MORGAN. I merely wanted to get at the question of how it was governed and by whom.

General DAVIS. There are several questions that are analogous to this type of canal, and I have made a list of some. I have made these titles: Earthquakes, Military questions affecting type, Submerged land, Malicious destruction of the canal possible, Time or method of construction, Panama Railroad management. Those are a few of the headings.

Senator MORGAN. We will go over those before we close your examination. We will take them up in such order as the members of the committee may prefer.

The CHAIRMAN. Are you through with the gentleman for this evening?

Senator MORGAN. Yes.

(Thereupon, at 4.20 o'clock, the committee adjourned until tomorrow, Friday, March 30, 1906, at 10.30 o'clock a. m.)

Commercial vessels over 12,000 gross tonnage.

[Principally from Lloyd's Register, 1906-6.]

Name.	Gross tonnage.	Dimensions.		Molded depth.	Maximum draft.	Speed.	Flag.
		Length.	Breadth.				
		<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Knots.</i>	
Mauritania (unfinished) ..	33,200	787.6	88.0	60.6	a 37.0	24	British.
Lusitania (unfinished) ..	38,200	787.6	88.0	60.6	a 37.0	24	Do.
Kaiserin A. Vic. (unfinished)	b 25,000	727.6	77.6	54.0	c 37.0	-----	German.
Adriatic (unfinished)	b 25,000	727.6	75.6	49.0	c 37.0	-----	British.
Baltic	23,876	709.2	75.6	52.6	a 37.3	17	Do.
Amerika	22,250	670.5	74.6	48.4	c 34.67	-----	German.
Cedric	21,085	680.9	75.3	44.1	a 36.93	17	British.
Celtic	20,904	680.9	75.3	44.1	a 36.77	17	Do.
Minnesota	20,718	622.0	73.5	41.5	c 30.58	14½	American.
Dakota	20,714	622.0	73.5	41.5	c 30.58	14½	Do.
Campania	19,594	650.0	72.2	40.2	c 29.62	19	British.
Caronia	19,594	650.0	72.2	40.2	c 29.62	19	Do.
Kaiser W. II.	19,361	684.3	72.3	40.2	a 30.0	20	German.
Oceanic	17,274	685.7	68.8	44.5	a 35.7	20	British.
Deutschland	16,502	660.9	67.5	40.3	c 29.7	20	German.
Arabic	15,801	600.7	65.5	47.6	c 33.0	16	British.
La Provence	15,000	607.0	61.7	38.0	c 28.0	-----	French.
Republic	15,378	570.0	67.8	d 24.0	-----	16	British.
Kron Prinz Wm	14,908	637.3	66.3	39.3	a 30.0	20	German.
Kaiser W. der G.	14,349	626.7	66.0	39.0	a 29.26	20	Do.
Saxonia	14,281	580.0	64.2	38.4	c 28.3	16	British.
Ivernia	14,058	582.0	64.9	37.8	c 28.26	16	Do.
Mongolia	13,639	600.0	65.3	31.1	c 22.92	16	American.
Manchuria	13,639	600.0	65.3	31.1	c 22.92	16	Do.
Carpathia	13,564	540.0	64.5	37.4	c 27.66	15	British.
Cretic	13,518	582.0	60.3	38.3	c 28.22	16	Do.
Patricia	13,424	560.3	62.3	37.1	c 27.84	13½	German.
Minnehaha	13,403	600.7	65.5	39.5	c 29.11	16	British.
Minneapolis	13,401	600.7	65.5	39.7	c 29.26	16	Do.
Minnetonka	13,396	600.7	65.5	39.7	c 29.26	16	Do.
Pennsylvania	13,333	569.4	62.2	30.0	c 22.11	13½	German.
Pretoria	13,234	561.0	62.3	37.9	c 27.98	13½	Do.
Graf Waldersee	13,193	561.2	62.2	37.7	c 27.78	13½	Do.
Grosser Kurfurst	13,182	560.6	62.3	35.9	a 26.18	13½	Do.
Cymric	13,096	585.5	64.3	37.9	a 31.06	15	British.
Kenilworth Castle	12,975	570.2	64.7	38.7	c 28.33	17½	Do.
Amadale Castle	12,973	570.1	64.5	39.0	c 28.74	17½	Do.
Lucania	12,962	601.0	65.2	37.8	c 28.25	22	Do.
Campania	12,960	601.0	65.2	37.8	c 28.25	22	Do.
Walmer Castle	12,546	570.5	64.4	38.6	c 28.44	17½	Do.
Finnland	12,760	560.0	60.2	38.4	c 28.3	16	American.
Kronland	12,760	560.0	60.2	38.4	c 28.3	16	Do.
Suevic	12,500	550.2	63.3	39.9	c 29.4	13	British.
Runic	12,482	550.2	63.3	39.9	c 29.4	13	Do.
Saxon	12,385	570.5	64.4	38.6	c 28.44	17½	Do.
Noordam	12,531	550.3	62.3	34.0	c 25.06	15	Dutch.
Potsdam	12,532	550.0	62.0	34.6	c 25.5	15	Do.
Rijndam	12,527	550.3	62.3	34.6	c 25.50	15	Do.
Kaiser Friedrich	12,480	581.7	63.7	37.9	c 27.98	-----	German.
Moltke	12,335	525.6	62.3	35.6	c 26.23	16½	Do.
Blucher	12,334	525.6	62.3	35.6	c 26.23	16½	Do.
Ionic	12,232	500.3	63.3	39.0	c 28.74	13	British.
Barbarossa	10,915	526.3	60.0	34.6	a 25.59	15½	German.
Athenic	12,234	500.3	63.3	39.0	c 28.74	13	British.
Canopic	12,097	578.3	59.3	35.8	c 26.38	16	Do.

a Reported draft as stated by owners.

b Approximately.

c Estimated draft as computed by ratio of molded depth to draft in case of 12 vessels whose draft is stated above; molded depth $\times 0.737$ = draft.

d Depth as stated in Lloyds, probably an error.

Grosser Kurfurst and Barbarossa have passed Suez Canal.

Naval vessels of 14,000 tons and over.

[Displacement Clowes' Naval Pocket Book, 1905.]

Name.	Flag.	Displacement.	Dimensions.		
			Length.	Beam.	Draft.
		<i>Tons.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>
Lord Nelson.....	British	16,500	410	79.5	27
Agamemnon.....	do	16,500	410	79.5	27
Africa.....	do	16,350	453.75	78	26.75
Britannia.....	do	16,350	453.75	78	26.75
Hibernia.....	do	16,350	453.75	78	26.75
New Zealand.....	do	16,350	453.75	78	26.75
Hindustan.....	do	16,350	453.75	78	26.75
King Edward.....	do	16,350	453.75	78	26.75
Dominion.....	do	16,350	453.75	78	26.75
Commonwealth.....	do	16,350	453.75	78	26.75
Queen.....	do	15,000	400	75	^a 27.75
Prince Wales.....	do	15,000	400	75	^a 27.75
London.....	do	15,000	400	75	^a 27.75
Bulwark.....	do	15,000	400	75	^a 27.75
Venerable.....	do	15,000	400	75	^a 27.75
Formidable.....	do	15,000	430	75	^a 27.75
Irresistible.....	do	15,000	430	75	^a 27.75
Implacable.....	do	15,000	430	75	^a 27.75
Cesar.....	do	14,900	413	75	27.50
Hannibal.....	do	14,900	413	75	27.50
Illustrious.....	do	14,900	413	75	27.50
Jupiter.....	do	14,900	413	75	27.50
Mars.....	do	14,900	413	75	27.50
Prince George.....	do	14,900	413	75	27.50
Victorious.....	do	14,900	413	75	27.50
Magnificent.....	do	14,900	413	75	27.50
Majestic.....	do	14,900	413	75	27.50
Duncan.....	do	14,000	429	75.5	26.50
Cornwallis.....	do	14,000	429	75.5	26.5
Exmouth.....	do	14,000	429	75.5	26.5
Russell.....	do	14,000	429	75.5	26.5
Albemarle.....	do	14,000	429	75.5	26.5
Montagu.....	do	14,000	429	75.5	26.5
Empress India.....	do	14,150	380	75	27.5
Ramilles.....	do	14,150	380	75	27.5
Repulse.....	do	14,150	380	75	27.5
Resolution.....	do	14,150	380	75	27.5
Revenge.....	do	14,150	380	75	27.5
Royal Oak.....	do	14,150	380	75	27.5
Royal Sovereign.....	do	14,150	380	75	27.5
Hood.....	do	14,150	380	75	27
Minotaur.....	do	14,600	490	74.6	26
Defence.....	do	14,600	490	74.6	26
Shannon.....	do	14,600	490	75.6	25
Drake.....	do	14,100	529.5	71	26
King Alfred.....	do	14,100	529.5	71	26
Leviathan.....	do	14,100	529.5	71	26
Good Hope ^b	do	14,100	529.5	71	26
Terrible ^b	do	14,400	538	71	30
Powerful.....	do	14,400	538	71	30
République.....	French	14,865	439	79.5	27.2
Patrie.....	do	14,865	439	79.5	27.2
Justice.....	do	14,865	439	79.5	27.2
Démocratie.....	do	14,865	439	79.5	27.2
Vérité.....	do	14,865	439	79.5	27.2
Sardegna.....	Italian	14,800	411	76.75	28.5
Lepanto.....	do	15,900	400.5	74	31.2
Italia.....	do	15,654	400.5	74	31.2
Katori.....	Japanese	16,600	455	78.2	26.66
Kashimi.....	do	15,200	432	76	27.25
Mikasa.....	do	15,200	432	76	27.25
Asahi.....	do	15,200	425.5	75.5	27.2
Shikishima.....	do	15,000	425.5	75.5	27.2
Imp. Pavel I.....	Russian	16,000	430	80	26
And. Pervosvanni.....	do	16,000	430	80	26
New Hampshire.....	American	17,650	456.3	76.8	^a 26.75
Kansas.....	do	17,650	456.3	76.66	^a 26.75
Minnesota.....	do	17,650	456.3	76.66	^a 26.75
Vermont.....	do	17,650	456.3	76.66	^a 26.75
Connecticut.....	do	17,650	456.3	76.83	^a 26.75
Louisiana.....	do	17,650	456.3	76.83	^a 26.75
Virginia.....	do	15,300	435	76.83	^a 26
Rhode Island.....	do	15,300	435	76.83	^a 26
New Jersey.....	do	15,300	435	76.83	^a 26
Nebraska.....	do	15,300	435	76.83	^a 26
Georgia.....	do	15,300	435	76.83	^a 26

^a Maximum draft.^b Has passed through the Suez Canal.

Naval vessels of 14,000 tons and over—Continued.

Name.	Flag.	Displacement.	Dimensions.		
			Length.	Beam.	Draft.
		<i>Tons.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>
Kentucky ^a	American	11,540	376	72.08	23.5
North Carolina.....	.....do	14,500	502	70	26.5
Montana .....	.....do	14,500	502	70	26.5
Tennessee .....	.....do	15,960	504.5	72.9	27.2
Washington .....	.....do	15,960	504.5	72.9	27.2
California .....	.....do	14,000	502	70	26.5
South Dakota.....do	14,000	502	70	26.5

^a *Kentucky* passed Suez Canal in 1902.^b Maximum draft

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ISTHMIAN CANAL.

COMMITTEE ON INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Friday, March 30, 1906.

The committee met at 10.30 o'clock a. m.

Present: Senators Millard (chairman), Kittredge, Dryden, Hopkins, Knox, Ankeny, Morgan, Taliaferro, and Simmons.

STATEMENT OF MAJ. GEN. GEORGE W. DAVIS, U. S. ARMY (RETIRED)—Continued.

The CHAIRMAN. General, we are ready now to have you proceed, if you have any further statements to make.

Senator KITTREDGE. General, do you think this work should be constructed by contract or directly by the Government?

General DAVIS. I feel that there is no doubt that the interests of the United States will lie in having this work done by contract throughout. I think there is no doubt of it.

Senator KITTREDGE. In what manner would you suggest that the contract be made, or propositions for a contract?

General DAVIS. I would of course first have careful specifications of the work made. I think that Mr. Stevens has stated in his testimony before your committee that he can prepare specifications for the canal in a month. I believe I have read such a statement of his; and I would have those specifications prepared. I should offer the work to contractors on the basis of payment by unit quantity, our engineers to determine what those unit quantities are. The specifications should state how far away the material is to be carried—that is to say, some maximum haul, perhaps, or else there should be a condition requiring that the material excavated should be so deposited away from the line of the canal as to insure no possibility of its return to the line of the canal, and that to be settled by the dicta of the Government's engineers.

If locks are to be built, they ought to be described in as much detail as will enable the contractor to tell what unit price to bid on yards of cement, cubic feet, or yards of cut granite for copings, etc., what price to bid per pound for wrought iron or steel used in the lock gates when they are finally incorporated, etc.; and all the

machinery should be so described that they can give unit estimates on it. The matter of machinery is not so important, however; that can be deferred a long time.

The specifications should recite where the material taken from these dredged entrance channels is to be deposited. If jetties are to be built, the specifications should state to what size they are to be carried. Then I would allow the contractor entire freedom of scope as to where he should get that material and as to where he should get his labor. I should tie him up with no conditions whatever, and I should turn over the Panama Railroad to him as a tool for him to use absolutely. Of course I should get a complete list of all the fixed and movable property, appraise its value when it was turned over to him, and under his contract require certain conditions to be fulfilled with respect to the return of that property when his contract should be finished. Of course a large part of it would be worn out; but that would be expected.

Senator KNOX. Would that contemplate abandoning the commercial use of the railroad?

General DAVIS. No, sir; I think not. I should delegate to this contractor the privileges which the United States enjoys by virtue of its ownership of the Panama Railroad in respect to the earnings it may secure, and should also transfer to him the obligations which the United States has assumed and put him in the light of a man holding a franchise—

Senator KNOX. A temporary lessee, as it were?

General DAVIS. Yes, sir; a temporary lessee; and require him to do that commercial work. I should treat the commercial work as a transfer proposition pure and simple, just as Dodd's Express or Westcott's Express, in New York City, is managed.

Senator ANKENY. Do you contemplate one large contract or numerous small ones?

General DAVIS. One large contract.

Senator ANKENY. For the whole?

General DAVIS. For everything; and I should require a bond of ten or fifteen or twenty millions, or fifty millions.

Senator ANKENY. Whatever is necessary?

General DAVIS. Yes, sir; there will be no trouble in obtaining a perfectly satisfactory bond of that sort.

Senator MORGAN. But in that case there would be no competitors?

General DAVIS. Oh, yes, Senator; I think there would be. I believe that if you should offer that work to contract on that basis, you would have half a dozen bids from this country and Europe. I am confident of that.

Senator MORGAN. But our people probably would not consent, General Davis, to have a European contractor work out that job.

General DAVIS. I do not think it is desirable; but European contractors are building railroads in the United States. A European chief engineer is putting the tunnel under the East River in New York for the Pennsylvania Railroad to-day.

Senator MORGAN. But they are not Government works?

General DAVIS. No, sir.

Senator DRYDEN. Will you state what advantage you think there will be in having it all let by one contract rather than by a number?

General DAVIS. You would have one man to deal with; you would have no issues, no questions, no controversies between several contractors. I can see that there would be a good many conflicts between the smaller contractors if there are several of them. It has been suggested by some that there might be a dozen principal contracts, but if one man is building locks, he wants to get material for those locks; he wants to get some of it from abroad; he wants to get some of it from the Isthmus, and he wants to hire labor. He needs to use in the construction of those locks some of the very same material that will be taken out of the Culebra or some other excavation. If he is working for one principal contractor, that can all be arranged with the greatest facility between those two men, while if he is contracting directly with the Government, and the man that is excavating the Culebra is working for the Government, and the man that is building the jetties in the harbor of Colon is working directly under the Government, all correspondence and all negotiations between those men will have to be carried through this third party, the engineer representing the Government. I think it would facilitate the work greatly to eliminate that "loop."

Senator DRYDEN. I agree with you in that view. I suppose your anticipation would be that the main contractor would sublet contracts?

General DAVIS. Oh, of course; of course.

Senator DRYDEN. But the great difference would be that there would be one supreme authority in the contract?

General DAVIS. That is it; that is the way I feel about it.

Senator DRYDEN. Who could actually dictate the relations between these subcontractors and what their responsibilities and duties were?

General DAVIS. I see no difficulty in meeting the point that Senator Morgan raises by inviting bids from American citizens only and specifying that all material used should be of American origin. There is no objection to that, if the Congress wishes to put in that condition.

Senator MORGAN. I am not to be understood as advocating that; but at the same time I am quite sure that it will create a great deal of controversy in the United States.

The CHAIRMAN. There are contractors in this country, Senator, who could carry on that work just as well as those abroad.

Senator DRYDEN. Of course General Davis contemplates that this main contract would be open for bids to all contractors who have the means and facilities and the ability to take and carry on a contract of that kind, so that I think it could hardly be said that it was so limited that it was not thrown open to responsible and fair competition?

General DAVIS. Yes, sir. I think you will get three or four bids from American contractors for the whole work from responsible people—two or three, anyhow. I am confident you will get two or three.

The CHAIRMAN. Do you understand that there are contractors abroad that would have greater facilities for carrying on this work than those in this country?

General DAVIS. I should say generally, yes, because I know that in Europe the habit is to do these works by contract in a very large way. For example, there is the contracting firm of Pearson & Company that is just now finishing the Tehuantepec Railroad. That is a matter of some fifteen or twenty million dollars. They are carrying on that work and are just completing it now. Then take the Argentine works, the harbors in the Argentine Republic (I refer to Buenos Ayres), a work, the cost of which has run up to fifty or sixty million dollars; it has all been done by contract; the engineering has been done by contract.

The Assouan dam is a peculiar case. The Egyptian government did not have the money to build the Assouan dam. They borrowed up to the limit of their authorization to borrow. They were tied up; they could not get any more credit, and they wanted the Assouan dam made. They said to a contractor by the name of Coode, I think—I am not quite certain—"Will you build the Assouan dam and furnish the money yourself, and take your pay in annuities?" He said: "Certainly; I am perfectly ready to do that." He went to work, made a contract with the Egyptian government, approved by Lord Cromer, and proceeded to build the Assouan dam, and built it inside of the time that he contracted for. He did his own engineering and turned over the completed work; and he is to receive \$200,000 a year for a certain number of years—I have forgotten the number—and that pays for the dam.

Senator KNOX. That is more in the nature of a concession than a contract?

General DAVIS. Rather more so; but still he did the work. He took the risks.

The CHAIRMAN. Where does he get labor—right where he is constructing the dam?

General DAVIS. Oh, he got the labor in Egypt—the fellaheen of Egypt.

The CHAIRMAN. But what would be the result in Panama, as to labor there?

General DAVIS. I think the contractor ought to have freedom to go where he pleases to get his labor.

The CHAIRMAN. To go wherever he saw fit, and to get any kind of labor?

General DAVIS. Our trade unions here do not want to go to Panama to work. Even our negroes in the South are not begging for the privilege of going down there to work. They are not asking for it or even offering to go.

The CHAIRMAN. I think the trade unions have made some suggestions as to the work at Panama.

General DAVIS. I have read in the papers that they have.

The CHAIRMAN. As to the hours, and the kind of labor that should be employed.

General DAVIS. I have read that they have; yes, sir.

The CHAIRMAN. But your idea would be, General, I think, to throw the work open to any kind of labor?

General DAVIS. I think the contractor ought to have the privilege of getting his labor where he pleases.

The CHAIRMAN. And to fix the hours, too?

General DAVIS. I think he ought to fix his own hours of work. I remember here last winter, indeed in this city, to have made a visit to the bridge that is being built over Rock Creek, and I asked the engineer officer if the eight-hour law bothered him at all. He said no; that that law applied to their own employees that were paid from the Government pay roll, but that the contractor paid no attention to it. I said: "Why, I do not understand that. I do not understand how he has escaped conformity with the law." He said: "The law happens to be so framed that no penalty is provided for its infraction, and the contractor knows that, and he proceeds without any regard to it."

That is in the District of Columbia. I am not vouching for the accuracy of the statement; I only know that I was so told by the engineer in charge.

Senator TALIAFERRO. Do you think, General Davis, that if this work is done by contract the railroad should be turned over to the contractor?

General DAVIS. I do not see how you can help it. I do not see how you can help it.

Senator ANKENY. You would not disturb the commercial business?

General DAVIS. Oh, no, sir; no, sir.

Senator ANKENY. The contractor would regulate his own work to the railroad business?

General DAVIS. I think if he was a wise contractor he would take very good care to increase it. He would seek to increase that commercial work if he was a wise man.

Senator TALIAFERRO. It would be your idea, however, that the Government should fix the commercial rates?

General DAVIS. Oh, of course they should fix an upset price which should not be exceeded for the transfer of freight across the Isthmus.

Senator TALIAFERRO. So as not to discourage that business?

General DAVIS. So as not to discourage it; no, sir; and then compel him to handle it and put him under penalties for failure to do so.

Senator TALIAFERRO. And give him the profits?

General DAVIS. And give him the profits—oh, yes. He ought to have the reward if he incurs the responsibility.

Senator TALIAFERRO. Ordinarily, of course, the Government would be entitled to something for the use of its property.

General DAVIS. Speaking of other engineering works, the jetty at Colombo is one of the greatest pieces of engineering in the world. There is scarcely any exceeding it in importance. You have there a jetty built of solid masonry that has to meet the whole northeast monsoon of the Indian Ocean. I have seen waves dashing against that jetty and rising a hundred feet into the air, with a noise like the booming of a cannon, when they pounded away at that jetty. That was all built by a contracting engineer, Sir John Coode & Co., of England.

The contracting engineers of Europe have had a scope much greater than our contractors in America have had. The subway contract is the only large one that I now recall over here.

Senator TALIAFERRO. General, a good deal has been said about the lands that would be submerged by these lakes—the one at Gatun, under the lock system, and the other at Bohio, is it?

General DAVIS. At Gamboa.

Senator TALIAFERRO. At Gamboa, under the sea-level system. Will you give us your views as to that?

General DAVIS. I stated them to the Board; I gave them all the data I had. I collected it while I was there as governor of the Zone. I cast up the quantity of land that we received by transfer from the French Company. I found the number of parcels and the claimed area, and then I computed the area of the Zone as represented by those very irregular lines. I found out what area of land the Panama Railroad claimed to own. I found out what particular parcels of land were known to be vested in the State at the time we took over the Zone. With that data I made up a tabulation of what looked to me like the way the equities lay—the way they were situated in respect to land ownership; and it is all printed in the report of the Board of Consulting Engineers. That data is all laid down there in the minutes of one of their meetings, I think. I can not recall just at this moment the amount; but, speaking generally, the claimed ownership of the United States to land received by purchase from the New French Canal Company and land received by virtue of its ownership of the stock of the Panama Railroad—there are those two categories—and the lands that it received by cession from the Republic of Panama, together make up, I think, about three-quarters of all the land in the Zone, so far as I could arrive at it by the best calculation I could make, in the making of which I had to do almost all of it as guessing. In other words, the data do not exist for making an accurate schedule of land ownership within the Canal Zone.

Senator ANKENY. Have they no records of deeds or titles, General?

General DAVIS. They have a record or deed of this sort: "Beginning at such a place on the bay, and running to a tree on top of a hill."

Senator ANKENY. Not any specific surveys, then?

General DAVIS. Oh, no; nothing specific—"thence to the corner of a fence somewhere else." They have no metes and bounds in the sense that the term should convey. But then I found that when we undertook to take possession of any particular piece of land and make use of it in some way, like constructing houses upon it, or something of that kind, I was very often tangled up with claimants of adverse possession, or of some right by prescription, or something of that kind; or else it would be asserted that this man had owned this land for so many generations, and the deeds had been burned up, and he did not know where they were, but it was a common, notorious fact that he owned that land, and that when that other person sold it to the French Company he sold something he did not own. And so the titles to land, and certainly the boundaries to the parcels of land in the Zone, are in a state of utmost confusion.

Senator ANKENY. Digressing a little, would it not be well, if we proceed with that work, to name a date in which all of these titles must be recorded or settled in some way, as we would do in Wyoming, for instance?

General DAVIS. I think the precedent that we followed in California is a good one.

Senator ANKENY. Yes.

General DAVIS. That of having a court of land titles, or whatever you may call it. You know the name better than I.

Senator ANKENY. Yes; I know about that.

General DAVIS. We did the same thing in the Philippines. There there is a "court of land" something; I do not recall the title.

Senator ANKENY. But ought there not to be some date on which these conflicting titles should be settled in some way, and the ownership at a certain date, for instance, established?

General DAVIS. The proposition of Governor Magoon seems to me an admirable one, and that is to announce by public advertisement.

Senator ANKENY. What did you do down there about this thing; anything?

General DAVIS. Oh, I could do nothing except to refer them to the courts and let them litigate, and they never got anywhere in the courts. That is to say, they never can reach any conclusion. Our courts had only been established in the Zone a very short time at the time that I refer to.

Senator ANKENY. Would it be possible for us to say that on such a date as your judgment dictated the titles to these lands must be recorded, or they would belong to our Government after that date? Could we do that?

General DAVIS. Oh, yes, sir; I think so.

Senator MORGAN. We can do any kind of robbery down there we want to. [Laughter.]

Senator ANKENY. That is not robbery, sir.

Senator MORGAN. There is no restraint on us that I know of.

Senator ANKENY. It is simply an adjustment of titles.

General DAVIS. I think there would be no trouble in adjusting those titles, but I think you would have to give public notice that every man can come in and make a "show down" of his pretension to title to this land and provide that this court shall then proceed to adjudicate as between A and B and C, and perhaps one of those will be the Government of the United States.

The CHAIRMAN. They will prove title by their neighbors down there, will they not?

General DAVIS. There will be all kinds of proof; there will be the tallest kind of swearing there.

The CHAIRMAN. Where are we going to swear, General? Have we any opportunity to do anything of that kind?

General DAVIS. We stand in about the same position that the Government always stands when it is a plaintiff in a suit. I have been connected with land condemnations here in the United States when I saw the United States, as I thought, robbed roundly; but there was no help for it.

The CHAIRMAN. I think we had better have a board appointed, then, and put the General at the head of it.

General DAVIS. We took the land by the right of eminent domain, and had appraisers, and all that; but the appraised value was something tremendous.

Senator ANKENY. Pardon me there just one moment. In that adjustment would you not first contemplate an official survey of our boundaries, for instance?

General DAVIS. I do not think our rectangular survey would be applicable there at all. There ought to be a survey of the whole Zone, of course.

Senator ANKENY. Meanderings and all?

General DAVIS. It ought to be a topographical survey, and then let everybody claim where he pretends his lines run.

Senator ANKENY. I do not see how you can proceed without it.

General DAVIS. It will have to be done, sir. It will have to be done, and it will unquestionably be done.

Senator KITTREDGE. In the event that a lock canal should be constructed at Panama, have you any opinion to express regarding the amount that it will cost us to pay for submerged lands?

General DAVIS. I stated before the Consulting Board that it was impossible for me to make an approximation to the figure that we would have to pay for the land. If I could answer the question by stating what I believe the land to be worth, I should say that the sum to be paid would not be large. But unfortunately the Government of the United States very seldom gets land by paying what it is worth. It is usual for the United States to pay three or four times the price of the land, and these Panamans understand the art of getting money out of their own Government or out of our Government or any government as well as the most skillful of our people do. I think we will have to pay very high prices for a great deal of this almost worthless land. I think it is inevitable that we will.

Senator MORGAN. Well, General, all of the questions about the condemnation of lands in the Zone and outside of the Zone are arranged pretty specifically by the Hay-Varilla treaty?

General DAVIS. Yes, sir; there is a plan provided.

Senator MORGAN. And commissioners have been appointed by both Governments to take up those cases and decide them?

General DAVIS. Yes, sir.

Senator MORGAN. What is the use of any intervention by the courts?

General DAVIS. I will try to answer that question by relating my own experience in attempting to carry out the orders of the Government.

It was decided by the Isthmian Canal Commission, and concurred in by the Secretary of War, that a certain parcel of ground adjoining land owned by the United States near the city of Panama was necessary for canal purposes. I was instructed, as governor, to take the preliminary steps and see if a purchase of that land could be effected. I had an interview with the owner and endeavored to get him to name a price. It was some time before he was willing to name any figure, but at last he did. The land in question was principally lying on the slopes of Ancon Hill; one-third of it, or perhaps one-half of it, was available for building purposes. The other portion was a steep declivity, reaching to the height of 630 feet, and useless for almost every purpose—that is, I mean to say these upper slopes.

At last the owner named a price which was, to my mind, about ten times the value of the land. I found out what he had paid for the land a few years before, and he was asking about ten times as much as he had paid a few years before. That is, he had bought it after the old French Canal Company had started on its boom; and yet he wanted ten times as much as he had paid.

I reported these facts. They told me to proceed under the treaty. I asked the Secretary of War to name two men to represent the United States in that board of arbitration. It is not called a board of arbitration, but a board of land appraisement. Notice was sent to the Panama Government to name two persons to represent it, proceeding always under the treaty. They did so. These four men met in the Isthmus of Panama and discussed the question of this land and its value. The Hay-Bunau-Varilla treaty provided for a fifth member of the board in case the four members could not agree. Fortunately it was not necessary to go as far as that; and the four men finally reached an agreement that we should pay for these thirty-odd acres of land, including one-third in a precipice, \$41,700 gold. That price was referred to Washington. The Commission and the War Department felt that they had pursued the legally required steps in arriving at the price, and that there was no likelihood of getting a lower price by resorting to the method provided in the treaty of selecting a referee, which referee had to be agreed upon by the two Governments; and as the time was passing, authority was given to me to proceed and accept the appraised price, inform the owner of the appraisement, and, if he was willing to accept it, let him proceed to make his deeds. He was notified; he made his deeds; they were recorded; the title passed to the United States, and the auditing department paid the money.

Senator MORGAN. What was the necessity for having such a high-priced piece of land there?

General DAVIS. It was deemed to be essential for the requirements of the canal. It was exactly on the edge of this very large hospital that the French company had built. There was not a square rod of land in that neighborhood where quarters could be erected for the Government officers.

Senator KNOX. How much did you pay for it more than it was really worth?

General DAVIS. I think about four or five times what it was worth. I think it was four or five times what the man could have gotten for it on the ground by private sale.

Senator DRYDEN. Were the appraisers on the part of the United States Government Americans?

General DAVIS. Yes, sir; both of them were Americans. Both of them were persons selected by the Secretary of War, and men of high character.

Senator KNOX. General, when you say that we paid four or five times as much as it was worth, what is the basis of your personal judgment as to the value?

General DAVIS. The prices at which transfers are made now and then of similar lands under similar conditions.

Senator KNOX. In the same locality?

General DAVIS. Not exactly the same locality, but close by.

Senator DRYDEN. Coming back to the cost of purchasing all these lands that are to be submerged, it has been stated by one witness that, in his judgment, it would probably cost the Government about \$18,000,000 to buy those lands. Have you read that?

General DAVIS. Yes, I know; I think I have read that, and I believe another man said twenty-five millions.

Senator DRYDEN. Yes.

General DAVIS. I do not think that the price would go up to any such figure; I think it will be a large figure, though I do not think it would go up to that amount. I can not see the basis for a figure so high as that.

Senator ANKENY. Approximately, in your opinion, what would it be?

General DAVIS. Oh, well, I am afraid to approximate it; but I think it will be some millions of dollars. I feel confident of that. I think the minority of the Commission stated some figures, and based some of their calculations on what the Panama Railroad paid per acre for similar land fifty-odd years ago. I do not think that that precedent has any value at all.

Senator KNOX. What is the character of these submerged areas—that is, the ones that it is proposed to submerge?

General DAVIS. Oh, they are low. Of course, all of the lands that will be submerged are necessarily lowlands.

Senator KNOX. Are they occupied?

General DAVIS. Only on the margins of the streams. Ninety-nine per cent of all the cultivated land in the Canal Zone is devoted to one crop, and that is bananas.

Senator KNOX. Then your fear that it will cost us a very large sum of money is not based upon the intrinsic value of the lands, but on the probability that we will be overreached in the proceedings to acquire it?

General DAVIS. Yes, sir; I think so. I do not think that the banana lands by themselves have an actual value, at the very outside, of \$100 an acre; and I think \$50 would be a high price.

Senator KNOX. Then, in its last analysis, it comes to this—that we will pay more than they are worth; that we are not able to take care of ourselves in the transaction.

General DAVIS. Precisely.

Senator TALIAFERRO. Is it not a fact, General, that all those lands have increased very largely in value since this Government bought that property?

General DAVIS. Oh, yes, sir; oh, yes, sir. There is no doubt that they have.

Senator TALIAFERRO. Because they feel that the canal is assured?

General DAVIS. Yes, sir.

Senator MORGAN. The treaty, though, positively forbids any addition to the price in consequence of the building of the canal, or the prospect of building it.

Senator DRYDEN. But that increase is largely speculative—almost wholly speculative; is it not, General?

General DAVIS. Oh, yes.

Senator DRYDEN. There has been no valid increase by reason of the owners being better able to get their crops into market that would justify the prices they are asking? There is nothing of that kind, is there?

General DAVIS. There are plenty of Americans down there now getting options on this land for the very purpose of finally unloading it on the Government.

Senator SIMMONS. General, are the Americans to whom you refer paying very high prices for those options?

General DAVIS. No; not a very high price. I do not think that it has gone on to any very large extent, but I know it was going on while I was there.

Senator SIMMONS. What are the exact provisions of this treaty with reference to this condemnation proceeding? You say the Government has two representatives. The Republic of Panama has two, I assume?

General DAVIS. Yes, sir.

Senator SIMMONS. And then how does the treaty provide for the umpire?

General DAVIS. The Hay-Bunau-Varilla treaty is as you state it with respect to that matter—that if the Government wishes to acquire any private lands they shall be appraised by a board consisting of two of its own delegates, the Panama Government shall be represented on the board by two other delegates of its own selection, and if these four can agree, well and good. If they can not agree, then a fifth man is to be called in and appointed by the two Governments. These four men are not to select him, but the two governments are to be informed that the four commissioners have failed to agree, and then the two governments are to enter into diplomatic negotiations or correspondence and finally decide who this fifth man shall be, and he then pronounces his decision.

Senator SIMMONS. While in the case that you recited a few minutes ago the Government seems to have been overreached in this arbitration under that system of appraisement, is there any reason why it should, as a general proposition, suffer? There is an equal chance for the other Government?

General DAVIS. Oh, certainly.

Senator SIMMONS. It participates in the selection of the umpire?

General DAVIS. Yes, sir; but one government is to pay the money and the other one has not any money to pay.

Senator SIMMONS. Your idea is that the sympathy would be with the Panamans?

General DAVIS. The one government, which has only a vicarious interest in it, would hardly feel as keenly the result as the one that had to respond.

Senator KNOX. General, leaving out the cities of Panama and Colon, is it likely that the whole Republic is worth \$18,000,000?

General DAVIS. Oh, I—

Senator KNOX. As a real-estate transaction, I mean?

General DAVIS. I should say that the answer to that would be "yes."

The CHAIRMAN. Do you not think that you might throw in Colon in that deal, General?

General DAVIS. Well, nearly all of Colon belongs to the Government now.

The CHAIRMAN. I understand that. I think it is a very poor asset, however.

Senator KITTREDGE. General, last evening you read a little memorandum of topics that you had in mind to speak about.

General DAVIS. I simply thought it possible that you might wish to question me on two or three of these other subjects. One was the Panama Railroad, which you have already alluded to; the military question as affecting the canal; earthquakes—

Senator KITTREDGE. I would like to hear you, very briefly, about the military features of the situation.

General DAVIS. I have read what those who have preceded me have said on that subject. I must say that what General Ernst said here a few days ago impressed me as having considerable force.

It seems to me that there are but two bases on which we can proceed with respect to the military aspects of the Panama Canal. One is to neutralize it, just exactly as the Suez Canal was neutralized in the Constantinople conference of 1888, and make it a neutral channel of communication entirely, as that was declared to be. I know that in 1882 the English Government closed it for a day or two, but in 1888 the Constantinople conference agreed that that canal should be neutralized forever.

Now, under that neutrality condition, which had been in effect before, this incident occurred: In 1870, when the Franco-Prussian war was going on, a French vessel and a German vessel both chanced to be in Lake Timsah at the same moment of time, and a state of war existed between the two nations. The date on which this occurred was the birthday of the Emperor of the French. The Frenchmen dressed ship, manned the yards, and fired a national salute, and the Germans did the same thing, in honor of the same event; and that was exactly while the Franco-German war was proceeding. So that in that canal there was entire friendship, entire harmony, entire peace. That is what is meant by neutralization.

✓ The other basis of procedure, it seems to me, is that the United States, as proprietor, as owner, as possessor of all that sovereignty, can give in the territory—shall say to all the world, "This canal is open to you, except in time of war, and in time of war we will shut it in your face if we please. We will close it if we want to."

We must take one of those two positions, it seems to me, with respect to the canal. Now, in the treaty by which the Clayton-Bulwer treaty was abrogated—I refer now to the Hay-Pauncefote treaty, the date of which I can not just now remember; of course it is the second one that was negotiated, the first having failed, but the second was ratified by both Governments—

Senator KITTREDGE. That was ratified four years ago last December, General.

General DAVIS. I had forgotten the date. Now, in that treaty there is a section that copies almost verbatim out of the Constantinople conference the whole provision about neutralization. That is all brought into this Hay-Pauncefote treaty; and these two Governments, the Government of Great Britain and that of the United States, have solemnly agreed upon neutralization of that canal by that treaty. Other powers are not a party to it, so far as I know; I presume they are not; but we must proceed on one of those bases, it seems to me—either shut the door in the face of anybody we please at any time we please, or else say, "It is open to you always."

What that may lead to I know—many dilemmas, many difficulties—but the situation is a difficult one.

Senator MORGAN. Now, General, is not this the proper interpretation of all of that doctrine: That the United States Government, being the owner of the canal, not in partnership with anybody else in its ownership or in its management, reserves to itself the right to re-

fuse to permit its enemy to use it in hostilities directed against the United States?

General DAVIS. That is rational; that is quite rational.

Senator MORGAN. And that is as far as we go in that proposition. But as between other belligerents the canal is neutral, and all the nations subscribe to the doctrine that it shall be kept neutral. Now, that would not apply to a war between Panama, for instance, and Cuba. They can get into war; they are small. Panama would have the right, as I understand the Hay-Varilla treaty and all the surrounding situation, to insist that Cuba should not be permitted to use that canal in belligerent operations against her; and if Cuba wanted to attack the city of Panama her vessels could not be permitted to go through the canal and get out into the bay and then make an attack upon Panama.

General DAVIS. No; that is forbidden by the Constantinople conference at Suez, which provides that the canal shall not be made the base of any military operations.

Senator MORGAN. Any at all?

General DAVIS. Any at all by anybody. That is declared firmly.

Senator MORGAN. Of course that means that it shall not be made the base of military operations amongst governments that did not own it. There was no government ownership of that canal at Suez?

General DAVIS. No, sir.

Senator MORGAN. And here there is a distinct ownership by the United States.

General DAVIS. I would have no difficulty in reconciling this with the principles you state, Senator, if it had not been that we have negotiated the Hay-Pauncefote treaty, in which we have declared that the principles of the Constantinople conference shall apply as between the United States and Great Britain.

Senator MORGAN. That means in like cases, but not as against the owner of the canal?

General DAVIS. The exception is not stated in the language of the law.

Senator MORGAN. I know that; but there are a great many things that are not stated in diplomatic parlance or language that are clearly reserved. That is my view of it. I did not care about participating in the expression of any opinion, but as the subject was up I thought I would state these things.

General DAVIS. I realize, gentlemen, that this is a subject that it is perhaps improper that I should discuss at all, for it is a very broad one and a very large one, and it is—

Senator MORGAN. The probability is that as long as this Government holds together it will never be discussed, because no nation would attempt to attack that canal while we held it, unless it was as a part of a general war against us.

Has any other gentleman any questions he wants to ask?

General DAVIS. There is just one other subject that I wanted to speak of, and that is the matter of earthquakes. There has been a good deal said here by various people about earthquakes. Now, I have read all that exists that I could get hold of respecting that phenomenon of nature which has been felt on the Isthmus of Panama; and that there is a danger from earthquakes there is as certain as

that we live. I presume the danger is difficult to appraise or to estimate; but that there is such a danger is unquestionable. I believe that danger exists everywhere. We did not think that it existed in 1884 at Charleston, S. C.; but we knew in 1886 that it did. And if an earthquake like the one that occurred at Charleston in 1886 (or was it 1887?) should occur at Panama, it would do harm. If such an earthquake as the Charleston earthquake occurred in Washington, it would perhaps demolish this building or injure it very much. It would unquestionably throw down the Washington Monument.

So this danger of earthquakes is one that you can not evade; it can not be foreseen; it can not be appraised. It exists, but I do not think that it has any particular signification. Its influence would be felt most seriously on structures and less on ditches, I think.

That is about all I can say about that subject.

Senator MORGAN. But, General, if you took a cube of basalt 8 or 10 miles long and 125 feet thick and 200 feet wide out of the backbone of that mountain, you might weaken it so that the earthquake would affect it very seriously, might you not?

General DAVIS. That is to say, that it would disturb the equilibrium of the mass?

Senator MORGAN. Yes.

General DAVIS. That is quite so; but here are hills and peaks rising up on the Isthmus of Panama all about you, with slopes quite as steep as are proposed for Culebra; and there they stand, and have stood for centuries. They are quite as steep, and they are all around. The Culebra Hill itself has precipitous slopes, and many, many of those hills have slopes that are—well, I know that Ancon Hill has a slope of 60°; I have measured it. That is right overhanging the city of Panama; and yet it stands there, and it is grassed over. It is true that such slopes stand on the Isthmus. They are earth slopes, too.

Senator MORGAN. Nevertheless, taking out such a cube of basalt as I have mentioned leading right through the backbone of the Isthmus would necessarily weaken it?

General DAVIS. But we would not have any slope, Senator, as abrupt as some of those that nature has left there.

Senator MORGAN. I am not speaking of the slope; I am talking about the weakening of the structure—the backbone.

General DAVIS. The strength of the slope, or the strength of an embankment, or of a declivity, or of a mass, is entirely proportionate to its slope or to its base. Now, if through natural causes—

Senator MORGAN. I am not speaking of tumbling down the top earth into the ditch. I am speaking about the effect of taking out that cube of basalt rock that binds the Isthmus. When an earthquake comes there, its effect will be very much more felt—more sensibly—than if the cube was there untouched?

General DAVIS. But how would that apply to the practicability of the canal, Senator?

Senator MORGAN. Why, if the canal was running through there I should think that there would be a great deal of dislocation.

General DAVIS. In other words, that the canal would be closed up? You are thinking about that?

Senator MORGAN. Yes.

General DAVIS. Then these banks are unstable; then that could not occur unless these banks are weak, unless this material would collapse, unless these side walls would slump off. The canal could not be closed unless something of that kind happened, could it? You could scarcely conceive that the floor would rise up.

Senator MORGAN. A lock or a sea gate would be almost certain to go under under those conditions.

General DAVIS. If we had a tidal wave on the coast there, yes; if it rolled in in a wave 60 feet high, as it did once on the coast of Peru, say, or as it did at the island of Santa Cruz in the West Indies.

Senator MORGAN. Have you any information in regard to the earthquake that occurred on the 31st of January of the present year?

General DAVIS. I only know of it by noticing a brief communication in the newspaper. I have not seen any extended account of it; no, sir.

Senator MORGAN. It seems that that incident has gotten out of public observation; I do not know how.

General DAVIS. It seems to have been some kind of a seismic wave that stretched across from Buenaventura on the Pacific side to Cartagena on the northern coast of South America.

Senator MORGAN. It passed clear across the neck?

General DAVIS. It appears so, from the account.

Senator MORGAN. It broke the cables on both sides?

General DAVIS. Well, cables are breaking all the time. We are having no end of trouble with cables. The cable breaks when we know nothing about what the cause was. I know that in the Philippines I had no end of trouble with the breaking of cables.

Senator MORGAN. But this broke one of these cables—the one on the Pacific side—in four places.

General DAVIS. I do not think that the fact that a cable is broken proves that it is done by earthquakes entirely.

Senator MORGAN. At all events, it is a recent disturbance of an important character?

General DAVIS. Yes, sir; yes, sir.

Senator MORGAN. And a tidal wave swept in there which, according to this newspaper account, pretty much destroyed Buenaventura.

General DAVIS. I do not know of the details, Senator. I have no information other than four or five lines that I read in the newspaper account.

Senator MORGAN. I mentioned that in support of your proposition that earthquakes have occurred and are just as apt to occur again as not.

General DAVIS. Yes.

Senator MORGAN. They have to be taken into the calculation in several respects.

General DAVIS. They have to be taken into the calculation everywhere. You know very well, Senator, how in California twenty-five or thirty years ago, in the city of San Francisco, it was considered that it was not safe to build any house more than two or three stories high, and that out of wood. That was the proposition on which they commenced to build San Francisco. It was believed that earthquakes would throw down everything that was in San Francisco unless it was of wood and of low altitude. They have gotten over that. They

are now building houses in San Francisco 10 and 12 stories high, out of steel and masonry, by the score. They are going up there all around and all about. They are watching the effect of vibrations on those buildings, and nobody seems to be concerned about their future. Of course we do not know what the future will bring forth.

Senator MORGAN. I do not think that this committee, in acting upon as serious a proposition as this, can fail to be concerned about anything that may occur rationally and that has occurred heretofore that will have an important bearing upon the success of this canal. We must be concerned with it, whether people are building skyscrapers or not; we must look at the facts.

I want to ask you something about the contour of the country between Bohio and Gamboa. It is the valley of the Chagres River running in there all the way across?

General DAVIS. Yes, sir.

Senator MORGAN. After you leave Bohio, going toward Gamboa, what would be about the narrowest width of that valley of the Chagres?

General DAVIS. Oh, the valley is of rather irregular, but still not extraordinarily irregular, widths. From Bohio to Gamboa I should say that the valley proper—I mean by that the portion of it that is not more than 30 or 40 or 50 feet above the sea—was a mile wide, in a general way.

Senator MORGAN. A mile wide?

General DAVIS. About a mile wide.

Senator MORGAN. That would be a fair average?

General DAVIS. Of course it is narrower and broader in parts.

Senator MORGAN. Yes; but that would be a fair average for the whole way up. Now, the Chagres River between Gamboa and Bohio meanders through this valley and cuts its way in frequent serpentine bends?

General DAVIS. Oh, yes; in many sharp bends.

Senator MORGAN. They are very numerous. Where does the railroad, as it stands to-day, cross the Chagres River?

General DAVIS. It crosses it at a place called Barbacoas, which is about a third of the way above Bohio, between Bohio and Gamboa.

Senator MORGAN. Above Bohio?

General DAVIS. Above Bohio.

Senator MORGAN. About a third of the distance?

General DAVIS. About a third, as I remember.

Senator MORGAN. That is the only crossing?

General DAVIS. That is the only place where the railroad crosses the Chagres.

Senator MORGAN. It used to cross at more than one place, but those have been taken out, I believe?

General DAVIS. No, sir; no; it never crossed but at one place that I ever heard of.

Senator MORGAN. And that was at Barbacoas?

General DAVIS. Barbacoas; yes.

Senator MORGAN. About what is the width of the valley at that railroad crossing?

General DAVIS. The railroad crosses at a place where the bank on the right-hand side approaches closely to the river channel by a high,

rocky bluff; a point juts out, and the line of rails coming up from Colon passes around this point and then shoots directly across the stream, so that one of the abutments of the present Barbacoas Bridge is this rocky promontory. Then there are, if I remember right, five spans in that bridge, each about 90 feet wide. It is a bridge made of iron and constructed in 1854 or 1855. It is the same identical bridge that is there now; and the whole width of the channel of the river at that point, I should say, was about, from memory—it is easy enough to tell by the larger maps—400 feet, I should think, the channel proper. I should hardly say the channel, but the river bed is about 400 feet wide at high water; the water width is perhaps 150 feet.

Senator MORGAN. The maps that I have seen of that region of the country, particularly those of the engineers, indicate that ridges of lower elevation lie somewhat parallel to the Culebra elevation, between that and the coastal plain going toward the Bay of Limon.

General DAVIS. The one impression upon your mind when you get upon a high point and look out over the Isthmus is of a multitude of peaks, of hills. You just see a multitude of small hills rising all about you. If you get upon a high point and look out, you can count 20 anywhere—I mean up in the interior.

Senator MORGAN. Still these are arranged in ridges, are they not?

General DAVIS. Scarcely so, because if you study the drainage of the country you can always tell how the land lies by the way the rivers run.

Senator MORGAN. Yes.

General DAVIS. The rivers lie in the bottom of these valleys, wherever they are placed.

Senator MORGAN. The point I wanted to get at was whether or not the ridges, if they are ridges, or these series of hills, run parallel to the Chagres River on both sides or whether they run across it?

General DAVIS. Oh, there is no system, sir, that could be designated, or that I could describe at all events, except that of a great mass of detached elevations, with hills going back from the river, constantly rising, rising, rising as you recede from the river, but the crest line always ragged and serrated and broken; and as these foothills come toward the river they consist of isolated peaks and little hogbacks and smaller and larger acclivities. I could not describe it as a system of ridges, Senator.

Senator MORGAN. Do the Culebra and Emperador Heights constitute a ridge?

General DAVIS. That is the continental divide, and it is the rising of the land at that point. I think 335 feet was the original elevation of the lowest point of the Culebra.

Senator MORGAN. Yes.

General DAVIS. On the left-hand side of the Culebra is the Culebra Hill itself, which gave name to the place. "Culebra" means "rattlesnake."

Senator MORGAN. Yes.

General DAVIS. And that hill rises to about 700 or 800 feet in height. I have been on the top of it. Almost opposite to it is another hill where Mr. Buneau-Varilla built a house, in which he lived. That hill has about 500 or 550 feet elevation, and the canal prism is excavated right

between those two hills. Going farther east is Emperador Hill, which is an isolated knoll that rises right up out of this general, approximately level country that extends from Obispo to Paraiso.

Senator MORGAN. The Emperador is on the east of the canal?

General DAVIS. The Emperador is on the west.

Senator MORGAN. On the west of the canal?

General DAVIS. The Emperador Hill and the village are on the west.

Senator MORGAN. And the Culebra is on the east?

General DAVIS. And the Culebra Hill is on the east side, sir.

Senator MORGAN. That is all right. Now, just at Gamboa, where the Chagres River makes a turn around a mountain, I suppose—

General DAVIS. Well, a hill; I do not think the word "mountain" is applicable.

Senator MORGAN. A hill?

General DAVIS. Yes.

Senator MORGAN. It has an elevation of 300 or 400 feet?

General DAVIS. Yes; something like that.

Senator MORGAN. In the turn of the Chagres River around that point, does this valley narrow or widen, looking across from any part of it?

General DAVIS. The Chagres Valley from Bohio up to Gamboa, and still above that point, preserves about the same general regimen; but as you go higher up the Chagres, as you go up half way to Alhajuela, the banks are closing in all the time and narrowing up; and when you reach Alhajuela, the gorge is very narrow. I have been above Alhajuela.

Senator MORGAN. Taking the point of this ridge around which the Chagres River bends, and looking across it in any direction from that point, would there be a valley a mile wide?

General DAVIS. Up and down?

Senator MORGAN. Across.

General DAVIS. Transversely?

Senator MORGAN. Transversely.

General DAVIS. The Obispo comes in at that point.

Senator MORGAN. I know it does.

General DAVIS. And it follows the lowest ground there is in its course.

Senator MORGAN. Take the two valleys together, if you please—the Obispo Valley and the Chagres Valley, or the Gamboa dam site in the Chagres Valley—if you get on this point of rising so that you can see across the country there is a valley there a mile wide?

General DAVIS. The Obispo or the valley of the Chagres, which?

Senator MORGAN. Both.

General DAVIS. Oh, the valley of the Chagres is approximately a mile wide, although there are many places where it is not half a mile wide.

Senator MORGAN. I am talking about this particular place.

General DAVIS. At that particular place where the Gamboa dam is proposed to be built, we know exactly what its width is there. It is all shown on these maps.

Senator MORGAN. You measured that in order to get locations for the abutments of the dam?

General DAVIS. Exactly; yes, sir.

Senator MORGAN. How is it below that?

General DAVIS. Below that it widens a little, and at places considerably, and then pitches in again, so that you have not a regular width at all; but at places I think it may be a mile wide.

Senator MORGAN. Now, take the axis of the canal, which has been located here as being a mile away from this dam that the majority propose to build there for the protection of the sea-level canal—

General DAVIS. Oh, it is not more than half a mile, Senator.

Senator MORGAN. Half a mile?

General DAVIS. Not a half a mile.

Senator MORGAN. I thought that was a mile.

General DAVIS. No; it is not more than a third of a mile.

Senator MORGAN. I will take the axis of the canal, then.

General DAVIS. Yes, sir.

Senator MORGAN. And also the dam. It is half a mile between the two?

General DAVIS. Yes, sir.

Senator MORGAN. Is that level ground, or comparatively level?

General DAVIS. No, no; not comparatively level. There is very little level ground anywhere in that region.

Senator MORGAN. I do not mean dead level, like a table top.

General DAVIS. Oh, no; I understand. But there are great varieties in the surface in almost any quarter of a mile. There are a good many changes of level in any quarter of a mile.

Senator MORGAN. I know; but are there any prominent ridges that come up and intercept it?

General DAVIS. No, sir.

Senator MORGAN. It is a valley? Generally described, it is a valley?

General DAVIS. Yes, sir; yes, sir.

Senator MORGAN. Then you put in the Obispo Valley, coming into that?

General DAVIS. Yes, sir.

Senator MORGAN. That still further widens the area between the ridges?

General DAVIS. At the point where it debouches, as you sail up the Chagres (as I have done in a canoe), you would not, unless told, know that there was any stream coming in there at all. There are some overhanging boughs, some overhanging trees, and they say: "That is the mouth of the Obispo." It does not look like anything but a bayou. I am talking now about low stages of the river.

Senator MORGAN. Yes.

General DAVIS. It is 30 or 40 feet wide, not more; and it looks just like a little bit of a turning-out place. But that is really where the Obispo comes in.

Senator MORGAN. I suppose, General, that the jungle is so thick through that country that by visual observation you can not tell much about it?

General DAVIS. You can not tell anything at all about it unless you cut it out.

Senator MORGAN. Until you cut it out?

General DAVIS. Until you cut it out; no, sir.

Senator MORGAN. It is as thick as that?

General DAVIS. Oh, yes; it is everywhere.

Senator MORGAN. The point that I am trying to get at, and to which I will direct your attention more particularly, is whether or not a retention basis can be put in below the Obispo dam so as to control or assist in controlling the flood waters coming out of the Obispo and the Chagres?

General DAVIS. There can be no dam built below the Gamboa dam, across the Chagres, and below the mouth of the Obispo. It can be done. It will cost four or five times as much as it will to build a dam at Gamboa.

Senator MORGAN. I do not mean to have you understand that I am discarding the Gamboa dam. I am letting that dam stand.

General DAVIS. Oh, I did not understand you, then.

Senator MORGAN. I am providing for a case in which your calculation might possibly prove too enthusiastic in favor of the retaining power of that dam as to the body of water above it.

General DAVIS. Yes, sir.

Senator MORGAN. And where you might have to construct another basin below that as a regulating work.

General DAVIS. If the idea be a sea-level canal, the canal would traverse this basin.

Senator MORGAN. I know it would.

General DAVIS. Because the canal axis must, or at least does, follow the lowest ground.

Senator MORGAN. Yes; but I have not a sea-level canal in my mind in asking this question.

General DAVIS. Oh, I see.

Senator MORGAN. Now, I will take such a basin as that: What would be the superficial area, or about the acreage, that could be gotten in there?

General DAVIS. Supposing that you put the proposed dam just below the mouth of the Obispo, if I understand you correctly?

Senator MORGAN. Well, yes.

General DAVIS. At the mouth of the Obispo, or just below it—I will say at Matachin?

Senator MORGAN. Yes.

General DAVIS. That is the name of a locality there that has been spoken of as a site for locks by somebody.

Senator MORGAN. Yes.

General DAVIS. The distance of Matachin from the proposed site of the Gamboa dam would be, at the most, three-quarters of a mile. Your reservoir, or your basin, would be three-quarters of a mile long.

Senator MORGAN. And how wide?

General DAVIS. It would be the width of the valley, depending on the height of your dam. But supposing your dam to be 50 feet above the present water level, I fancy that the reservoir in that space would be half a mile wide—something like that. This is only approximate guessing. I could not give it any more accurately than by saying that it would be half a mile wide, and three-quarters of a mile from your proposed dam up to the Gamboa dam.

Senator MORGAN. Is there room for a sea-level canal and also for a drainage canal—I will call it a drainage canal—or an opening to convey the flood waters that may escape from the Gamboa dam along the general direction of the Chagres River, cutting across it when it is necessary to go across it, so as to reach the Gigante River, and pass

that water out through the watershed of the Gigante into the Peña Blanca Swamp or any other stream beyond?

General DAVIS. No; you can not do that, Senator.

Senator MORGAN. You can not do it!

General DAVIS. No, sir; nature is against you. The spillway of the Gigante is about 70 feet above the sea; and it would be necessary, in order to keep the water up to that level from the Obispo all the way down there, to build an embankment alongside of the sea-level canal 70 feet high all that distance—14 miles, or something like that—which would be an impossible proposition.

Senator MORGAN. Unless you took the spoil out of the sea-level canal and built a bank of it.

General DAVIS. Oh, yes; but there are methods of treating it which are so much better than that that it seems to me that should be discarded at once; because you can not make the Gigante reverse its flow over its own sources 70 feet high, and feed water into it that comes at a level of 40 or 30 feet or some other lower level.

Senator MORGAN. A dam at the proposed site at Bohio would not be sufficient to carry the water across the watershed into the Peña Blanca Swamp?

General DAVIS. I do not think I quite catch the question.

Senator MORGAN. You build a dam across the mouth of the Gigante River for the purpose of throwing the water back over its watershed?

General DAVIS. Yes, sir.

Senator MORGAN. How high would that dam have to be?

General DAVIS. That dam will have to be—I can not tell you now which is which, but one is 45, and one is 55, and one is about 65 feet high. There are three of those dams.

Senator MORGAN. That is only half as high as the Gamboa dam?

General DAVIS. Yes, sir; something like that.

Senator MORGAN. Only half as high?

General DAVIS. Something like that.

Senator MORGAN. So that it would be practicable, with a dam of that sort, to collect the overflow of the waters from the Obispo or from the upper Chagres that might escape the Gamboa dam and take it out with that dam 50 or 60 feet high across the watershed of the Gigante?

General DAVIS. But you would have a tremendous proposition to carry a channel for that water all the way down to the Gigante. It is miles and miles of distance that you would have to carry that water before it would get to the Gigante.

Senator MORGAN. It does not appear to me to be any more formidable a proposition than shutting the affluents out of the sea-level canal.

General DAVIS. The Obispo, three hundred days in the year, is a brook that you can step across.

Senator MORGAN. So much the better for the work.

General DAVIS. It is a brook you can step across; but in the times of flood it is a roaring torrent, just boiling with mud and water.

Senator MORGAN. And it gets very high very quickly?

General DAVIS. Yes; it gets very high very quickly, and it goes down just as quickly as it goes up. But that stream, under its active conditions, under its most violent moods, is going to send down, perhaps, 10,000 second-feet of water—something like that. I can not say, right offhand, what it is, and as I told you yesterday

the River Weaver empties 38,000 second-feet into the Manchester Canal every year at times of flood.

Senator MORGAN. I know about the comparison between that and the Manchester Canal, but at the same time, while I am not exactly alarmed, I am pretty apprehensive as to the Obispo, which is not taken care of by the Gamboa dam at all.

General DAVIS. No, sir; there is no attempt to take care of it by that dam.

Senator MORGAN. I am apprehensive that that Obispo River, pouring into a sea-level canal, might give you a great deal of discomfort, if not danger.

General DAVIS. There is one phase of this case, or one uncertainty about it, that perhaps may be cleared up by a statement, and I judge from the questions of other witnesses before the committee that there is some misunderstanding about it. That is this: The diversion channels proposed by the majority for the Chagres River are to be used only during the period of construction. As soon as the canal is made those diversion channels may grow up to jungle, or be filled up or disappear and be obliterated. The canal itself becomes the ultimate drainage of the whole country. The canal itself carries off all the flood flow after it is once made.

Senator HOPKINS. Does all the water of the Chagres River flow into the sea-level canal under that plan?

General DAVIS. Every drop of it that went into the canal at all would come in through the Gamboa dam, and that would be a regulated flow of never to exceed 15,000 second-feet, and always perfectly clear, limpid water.

That is the proposition of the majority, after the canal is once made. These diversion channels will be convenient accessories during the making of the canal, but after it is once made, then the majority propose to discontinue the use of the diversion channels and let the water take its lowest level for escape to the sea, which is the canal itself.

As to these figures that I read yesterday in regard to the storage capacity of the Gamboa dam, it is a fact (which is as certain as that we know how much water passes over the Great Falls of the Potomac) that the mean flow of the Chagres River for thirteen years was 3,164 second-feet; that is, the mean flow of the river, taking no account of four or five floods that may occur in a year. In the year I was on the Isthmus there was not a flood at all that would raise the water 5 or 6 feet. But those floods do occur once in a while. Leaving out the question of floods, 3,164 second-feet is all the water there is in the Chagres River at Gamboa. There is not another drop there. Now, to allow 3,164 second-feet to flow into the canal is nothing; it is a mere trifle; it counts for nothing; it is insignificant.

As I read yesterday, the biggest flood that ever occurred in the Chagres River in the history of man, at least so far as man knows anything about it, was in the flood of 1879, when, according to the testimony of one individual (Mr. Sosa), the water at Gamboa got up 36 feet. He says that the natives told him that the water went up to such and such and such a point, and he made a note of it in his notebook, and that is the record on which that flood of 1879 is computed.

That flood probably sent out a flow at Gamboa for a few minutes, maybe an hour, of 79,000 second-feet, according to the calculations of

General Abbot, who has spent years upon this study and is one of the most competent men that there is in the United States or in the world for the study of engineering questions of that character. He has stated in published reports that he has made that the mean flow of that flood of 1879 at Gamboa was 65,250 second-feet for forty-eight hours. We know that it only lasted forty-eight hours; that is history. We hear from this testimony of Mr. Sosa, based upon what natives had told him, that it did go up to 36 feet of rise at Gamboa. Now, assuming those two things as facts—and they are certainly interpreted in favor of the maximum quantity—that Chagres flood of 1879 at Gamboa would not more than one-quarter fill the Gamboa dam. The whole flood of forty-eight hours would only one-quarter fill it.

Senator MORGAN. Then what is the use of having any dam at Gamboa at all?

General DAVIS. Because these tremendous floods will put an end to navigation. We can not take 65,000 second-feet into the canal and maintain navigation. The dam is necessary to keep out all the silt and all the gravel that is rolled along the bottom, and all the bowlders and drift that would come tearing down there.

Senator MORGAN. And also to supply water in the case of a deficiency in very dry time?

General DAVIS. We do not care anything about that for a sea-level canal.

Senator MORGAN. Oh, no; not for a sea-level canal. Then it is exclusively a protection against floods?

General DAVIS. It is purely regulating works. Incidentally, it would be used to develop power for electric lighting and to run a trolley railroad, etc.

Senator MORGAN. Of course it would develop a very great power for such purposes?

General DAVIS. Oh, yes; it would develop many, many thousand horsepower. I have forgotten how many; but it is very easy to compute it.

Senator KITTREDGE. I have forgotten for the moment the height of that dam above the surface.

General DAVIS. Above the surface?

Senator KITTREDGE. Yes.

General DAVIS. It is 130 feet above the surface of the ground.

Senator KITTREDGE. And, as I recall it, it is about 55 feet from the surface to the bed rock?

General DAVIS. Yes, sir.

Senator MORGAN. General, in digging a sea-level canal from the Bay of Limon to Gamboa, you would, I suppose, get as close as you conveniently could to the hills that are on the right bank of the Chagres River?

General DAVIS. Yes, sir.

Senator MORGAN. You would have to trim off certain points in order to get your lines straightened out?

General DAVIS. The hills on the right bank, you say?

Senator MORGAN. On the right bank.

General DAVIS. I should take the most favorable location for the canal, wherever it was, without regard to any particular bank.

Senator MORGAN. Yes; you would take the favorable location, and cut the bank away?

General DAVIS. Yes; I would straighten the bends and get the necessary width and curvature, etc.

Senator MORGAN. Is it not practicable, in dealing with the sea-level canal on that plan, to utilize the spoil out of the canal, and particularly between Bohio and Gamboa, so as to make a formidable protection or wall against any other water that comes down from the Obispo or the Chagres or anywhere else? You would get it across your canal.

General DAVIS. To utilize the spoil for building an embankment between Bohio and Gamboa?

Senator MORGAN. Yes; utilize the spoil so as to build the embankment next to the river as you come on up, or next to the low ground; throw the spoil on one side. The hills are on one side.

General DAVIS. Where do the tributary streams come in? Some of them are mere rivulets, the size of your wrist or arm, and others are of considerable volume in times of flood. Those little brooks would be interrupted by such an embankment as you speak of.

Senator MORGAN. No, no.

General DAVIS. Then I do not understand your question.

Senator MORGAN. They would be let into the canal freely. They come out of the hills?

General DAVIS. Yes; they come out of the hills.

Senator MORGAN. We would throw all the spoil in the embankment on the other side, toward the river. I am coming up the right bank of the Chagres River, and throwing all the spoil out of the cut.

General DAVIS. These tributary streams would sweep it all back into the canal unless they were controlled by systematic means and weirs provided.

Senator MORGAN. But you have the tributary streams on the wrong side, I think.

General DAVIS. There are tributary streams on both sides, you know.

Senator MORGAN. I understand that; and I understand that they have to be dammed off. Those that come in on the left bank of the Chagres River have to be controlled by dams?

General DAVIS. Yes.

Senator MORGAN. Each dam being applicable to each stream?

General DAVIS. Yes.

Senator MORGAN. Very good. On the other side, on the right bank of the river, the streams are smaller, not so numerous, and, if I have understood you correctly, there is not much of a channel to be dug to divert them?

General DAVIS. The depth of excavation for a sea-level canal from Bohio to Gamboa ranges all the way from a mean of, I will say, 45 feet at Bohio up to the mouth of the Obispo, or from the bottom of the canal—which, you will remember, is 40 feet below the sea—of 75, 80, or 85 feet.

Senator MORGAN. Let us put it at 85 feet, so as to get it clearly.

General DAVIS. Yes; something like that.

Senator MORGAN. All right; 85 feet. In digging that canal you would have to take out a good deal of earth between Bohio and Gamboa?

General DAVIS. Oh, a great deal.

Senator MORGAN. Very good.

General DAVIS. By the way, I happen to remember now that the sea-level canal from the mouth of the Mindi to Gamboa involves the excavation of 95,000,000 yards of material.

Senator MORGAN. Very good. Now, take those 95,000,000 yards, if you please, and throw them away from the bordering hills on the right bank of the Chagres River and run your canal as close to the hills as you can conveniently and economically get it.

General DAVIS. Yes.

Senator MORGAN. And throw all of the spoil out of this canal—there is a great deal of earth there—in the direction of the Chagres River, so as to make an embankment to fence it off.

General DAVIS. Yes.

Senator MORGAN. Would not that be a great protection to it, if you got the Chagres River across your canal at some place?

General DAVIS. I can not see, Senator, how you could arrive at any condition of affairs that would be as favorable as it would to follow the idea that the majority recommends. It seems to me that that is reducing the thing to its simplest terms.

Senator MORGAN. Your idea of building the canal is that the simplest way to build it and the cheapest way and the most economical way is to follow practically, in a general sense, the flow of the Chagres River?

General DAVIS. Yes, sir; I think so.

Senator MORGAN. And take that river in as you go along?

General DAVIS. Yes; take that river in as you go along, after you have your canal finished. After the canal is made, then take in the regulated flow of that river.

Senator MORGAN. I have never seen why it is necessary to take it out while you are digging the canal, if you dredge it.

General DAVIS. When you get up, Senator, to a place where, we will say, the present floor of the river is at 40 feet above the sea and your canal is 40 feet below the sea, therefore in working there with your dredges you have a breast 80 feet high, 40 feet of which is out of water. Is that thinkable?

Senator MORGAN. I can see that that 40 feet out of water would have to be dug away.

General DAVIS. And 40 feet below.

Senator MORGAN. That would have to be dredged.

General DAVIS. And the dredges are floating in this channel already made up to this point 40 feet deep.

Senator MORGAN. Yes.

General DAVIS. Now, there is a breast ahead of you that is 40 feet high, and over the head of which is coming the flow of the Chagres River. Is that clear?

Senator MORGAN. Yes; so that you have to fence it out in order to dig it?

General DAVIS. Yes; that is it.

Senator MORGAN. That is one of the very great expenses, in my conception, that you will have all the time you are digging that canal. You will have to fence out the Chagres River and make a dry digging of it all the way through.

General DAVIS. This will happen in the construction of that canal (it will not be any great calamity, but this will happen) : The engineers will try to carry the flood flow of this river in these diversion channels, but until the time the Gamboa dam is made these diversion channels will be inadequate to carry the Chagres flood at times. It is perfectly well understood that that will be so. What will happen? That flood will come along, bearing down there while these dredges are at work, and it will interrupt things. It will fill up some of the workings; it will flood the whole thing for the time being.

Senator MORGAN. And wash everything out to sea?

General DAVIS. Not everything; no. The dredges will be moored; they will be kept there. The floods will sweep out the false work; they will do ten or fifteen or twenty or fifty thousand dollars' damage, perhaps, and in a week's time they will be going ahead again.

Those things happen in all these great big works everywhere. Such a thing happened in the Sweetwater dam yesterday, where the false works were swept out. But that is not going to discourage them from going right ahead again and building a dam there.

So in the building of the Susquehanna dam that Mr. Parsons is at work at now; he is going to have trouble. He is going to have floods of 600,000 second-feet in the Susquehanna River to contend with, and he is going to lose a lot of money for his employers at times by the accidents of these sudden rises. But that is not going to stop the work.

Those accidents are going to occur at Panama in just that way, with any kind of a canal that is built. They are going to have accidents, and they are going to cost some money; but they will be overcome in the end.

Senator MORGAN. Your apprehensions about the effect of the Chagres River pouring over this embankment and interrupting the work indicate that no part, or a very small part, of the work between the Bay of Limon and Gamboa can be done by dredges?

General DAVIS. A very small part of the rockwork can be done by dredges, Senator. I think there is a very small part of that.

Senator MORGAN. Or any other work?

General DAVIS. If we had unlimited space to work dredges against, what we call a "breast," if we had a mile stretch to put them and work in, we could think out plans for doing it. But where you have only 150 or 200 feet of width, with a breast 200 feet wide and 60 or 70 or 80 feet high, and you are working always against that breast, your rate of progress would be so slow that you would not get the canal made in a hundred years.

Senator MORGAN. Then, in any calculations or judgment we may arrive at about this matter we must eliminate the dredge?

General DAVIS. You will have to eliminate the dredge in all that rockwork as cutting any considerable figure.

Senator MORGAN. You say "rockwork;" but it seems to me it applies as well to the earthwork as it does to the rockwork.

General DAVIS. I say "rockwork" because the rock happens to be found where the cutting is deepest. That happens to be the case.

You know what Mr. Bunau-Varilla's ingenious idea is—to do all of this work under water. He says that you can take rock out under water so much cheaper than you can take it out dry. That is the basis of his argument. And yet the MacArthur Brothers, who are

improving the Hay Lake channel up there near the Soo, and who had a contract based on about \$2.80 for the excavation of rock under water, instead of doing it under water have gone to work and built a bulkhead at each end of a 3-mile stretch and pumped it all out, so that they can do it in the dry.

Senator MORGAN. It results from the little discussion we have just been having, it seems to me, that all the hauling down there will have to be done by railroad.

General DAVIS. I think that all of the Culebra hauling will have to be done by rail, Senator.

Senator MORGAN. Not the Culebra, merely?

General DAVIS. All of the deep cutting will have to be done by rail. Where it is a dredging proposition and the earth and the rock are at no very great depth, the dredges will do the work. You can start them in at more than one place.

Senator MORGAN. That applies to both types of canal?

General DAVIS. Yes, sir.

Senator MORGAN. Equally?

General DAVIS. Not equally, no; because the amount of excavation is different in the two types of canal.

Senator MORGAN. I mean in an equal degree?

General DAVIS. Yes, in an equal degree; to the extent to which their excavations apply; certainly.

Senator MORGAN. Yes. That means that the steam shovel and the railroad are the great implements with which this canal is to be dug, whether it is a sea-level or a lock canal?

General DAVIS. Yes, sir; all the upper part of it, all the deep part of it; but the low, level parts will be done by the dredge.

Senator MORGAN. From Bohio to Port Limon?

General DAVIS. From the sea up to Bohio and up to Miraflores.

Senator MORGAN. That would be done by dredging?

General DAVIS. Oh, yes; that will be done by dredging.

Senator MORGAN. That is 20 miles including those dredging lines?

General DAVIS. It is 17 miles from Limon Bay to Bohio; it is about 7 miles from the Pacific end up to Miraflores. That is about 24.

Senator MORGAN. Twenty-four miles?

General DAVIS. Just about half of the line is a dredging proposition.

Senator MORGAN. The dredging proposition, then, would cover just about half of the entire length of the canal?

General DAVIS. Yes; and a little of the work above Bohio is a dredging proposition, too—a couple of miles or so above Bohio. At Bohio, you know, we cut through a spur.

Senator MORGAN. Yes; from Miraflores into the Pacific Ocean, as deep as you would want to go down to the 40-foot contour, you can go with dredges?

General DAVIS. Yes, sir; you can do all of that work by dredges. Some of it is rock, but you could blast the rock and take it out with dredges.

Senator MORGAN. And from Bohio to the Bay of Limon you can do it with dredges?

General DAVIS. Yes, sir.

Senator MORGAN. You can do the work with dredges?

General DAVIS. Yes, sir.

Senator MORGAN. And in the interval between Bohio and Gamboa you would have to work in the dry?

General DAVIS. A good deal of the way; but there is some part of that distance that can be dredged.

Senator MORGAN. There are probably a couple of miles that you could dredge above Bohio?

General DAVIS. There are two or three miles, maybe, of dredging proposition in there.

Senator MORGAN. Then that would leave about 15 miles?

General DAVIS. Something like that.

Senator MORGAN. Of dry work?

General DAVIS. Of dry work; yes, sir.

Senator MORGAN. Over the whole of it?

General DAVIS. Yes.

Senator MORGAN. All but 15 miles of it could be done with dredges?

General DAVIS. I do not mean to say that dredges would not be used to some extent all the way to Gamboa. I think they would be to some extent; but all of the great mass of the top work down to the sea level will have to be taken off in the dry.

Senator MORGAN. Then after you got your canal all dug, equipped, and everything of the sort, you would not have any use for the Gamboa dam?

General DAVIS. After we have the canal made?

Senator MORGAN. Yes.

General DAVIS. Oh, my dear sir, yes. That is the time that its use becomes most important—that is, to regulate and control these floods.

Senator MORGAN. Then I am mistaken in my understanding of your testimony that after the canal is completed at sea level it will take care of all of the waters of the Chagres River?

General DAVIS. It will take care of all the water in a regulated flow.

Senator MORGAN. Oh, you mean that?

General DAVIS. Oh, yes; I mean that, of course.

Senator MORGAN. You do not propose to dispense with that dam?

General DAVIS. Oh, by no means; no, sir.

Senator MORGAN. So that dam is put there for good and all?

General DAVIS. For good and all, to remain there forever, and to regulate the flow of the Chagres River for all time, and to spill the water of that river out just as slowly as we wish to and as fast as we wish to.

Senator MORGAN. Yes. Now, suppose, General, that Congress should come to the conclusion that the most economical and the quickest and the best way at present to build that canal would be to build a lock canal, with locks in the vicinity of Gamboa, say, a mile apart, of 30 feet elevation, and locks in the vicinity of Miraflores, at a proper distance, about 30 feet elevation, and with two locks on each side; that would leave a 60-foot elevation above the level of the sea, cutting down the Culebra and Emperador heights until you got down to the 60-foot level?

General DAVIS. Yes, sir.

Senator MORGAN. Suppose that the two Houses of Congress and the President should come to the conclusion that, after all, a sea-level canal, reaching to Gamboa, or in that vicinity, and from Miraflores out to the 40-foot contour in the Bay of Panama, would be the best

and the cheapest, and that it would at the same time enable the engineers, in the construction of this work, to determine, before these sea-level reaches could be dredged and completed, whether it was better or not better to take out that cube of earth and rock (most of it rock) between Gamboa and Miraflores. The point I want to get at is this: If you dredged your canal up to Gamboa, in pursuance of such a suggestion as I have made, is there any difficulty in that soil and at that place in putting in two locks, say, half a mile apart, but not in flights, or a mile apart? Is the soil adapted to putting locks into that canal?

General DAVIS. The answer is very easy. The situation at Obispo is not difficult to see from this map. The point to which Senator Morgan's question relates is here [indicating]. You see the figure "31" there; that means 31 miles from Colon. The village of Obispo stands right here. Here we come into a straight tangent, or nearly so, approaching the Culebra. These locks, if located, must not be farther to the eastward than 31. They must come in this space. The locks on the other side would be, one at Miraflores and one at Pedro Miguel, here [indicating].

The situation which is described in the question will, I think, leave a lock canal infinitely to be preferred to the lock canal which the minority recommends. I think this is a situation in which two locks can be placed, one circumstance only opposing it, and that is that this approach to the lock is a curve—a curve that can not be dispensed with. It is inevitable. It happens to be one of the four sharpest curves in the whole canal line, the radius from this center point being 8,200 feet.

That is the only unfavorable feature. But two locks can be placed here, and two can be placed on the west side or the southwest side; and that will leave a sea-level canal to Gamboa and a sea-level canal to Miraflores, with an elevation 60 feet high interposed—that is, with an elevation 60 feet high minus the depth of the canal itself, which is 40 feet. Therefore the floor of the canal will be 20 feet above the level of the sea; and 40 feet to its own bottom will leave a height of land interposed of 60 feet.

I think that before the engineers get through with the making of that canal they will be very impatient to get authority from the Commission or the Government or somebody to take out those other thirty, forty, or fifty million yards.

Senator MORGAN. The great proposition involved in the question I put is just this: That in constructing a canal on the plan I have mentioned, starting the construction and carrying it on the plan I have mentioned, it is practicable to ascertain by the cost of various kinds of work and cost of transportation and all other costs connected with it almost the exact value of taking out this cube between Gamboa and Miraflores.

General DAVIS. Yes, sir.

Senator MORGAN. And when you have dug down to 60 feet, probably you will have dredged in as far as Bohio, at least, or you may possibly have dredged in as far as Gamboa, and on the other side you will have dredged in to Miraflores.

General DAVIS. Yes, sir.

Senator MORGAN. And then, aided by the lessons of experience and observation, and also assisted in coming to our conclusions by

the financial condition of the country, it could be ascertained with more satisfaction than it is possible to ascertain by a present conjecture or present calculation as to whether that great cube of stone between Gamboa and Miraflores could be economically removed, and bring the whole canal to sea-level. That strikes me as being one of the elements in a recommendation on this proposition which is a very important one, considering all the situation, and particularly the state of public opinion, which, before this canal is ever built down to a sea-level, will have to crystallize and ripen in favor of it through observation and experience.

General DAVIS. Yes, sir.

Senator MORGAN. Now, I have seen a plan which occurs to me as being a very important one and, I believe, a practical solution of the difficulty of getting rid of any possible interruption or interference by the Chagres River after the Gamboa dam is completed. That is to unite with the Gamboa dam a viaduct crossing the Chagres River at the elevation of 60 feet above the sea level, that viaduct to be approached from the northward or eastward, the eastern end to be connected by a lock of 30 feet elevation, with another lock a half a mile or a mile distant, that having another 30 feet of elevation, where it would connect with the sea-level cutting; and, on the other hand, having at Miraflores and Pedro Miguel locks of the same elevation that would let the water down or let it up, as the case might be, into a lock canal; the lock canal to be supplied and regulated through this viaduct or into this viaduct from the Gamboa dam.

General DAVIS. I think I have seen some plan that answers the description you give.

Senator MORGAN. I wish, before we close this examination, that I may have the privilege of submitting a question to you upon this basis, and asking you for your judgment as to its practicability. I call attention to it now, Mr. Chairman, because I will hand General Davis at a proper time that question, and let him give us in writing—if the committee is willing—a statement of his opinion upon the practicability of that plan. I will hand you the question some time during the day, General, if you please.

General DAVIS. Yes, sir; I will be very glad to have it.

Senator MORGAN. And I will ask permission that General Davis may put his reply to that question, which I will read to the committee before I hand it to him, into his examination, as if he was here present when the question was asked.

The CHAIRMAN. Do you wish to put it in writing?

Senator MORGAN. Yes; to put it in writing, and to just put the question and the answer to that simple proposition in the record.

Senator ANKENY. Does that contemplate a division of the Chagres waters east and west?

Senator KITTREDGE. It will explain itself.

Senator MORGAN. Yes. It contemplates the filling of the prism of the canal between Gamboa and Miraflores with Chagres water, fresh water. The balance of the canal on either side would be filled, of course, by similar water coming from the sea on either side.

Senator KITTREDGE. What is the character of the foundations at that point?

General DAVIS. At Gamboa?

Senator KITTREDGE. At Obispo.

General DAVIS. Rock—conglomerate, hard conglomerate.

Senator KITTREDGE. How near the surface?

General DAVIS. It crops out away up; it is all around Obispo.

Senator KITTREDGE. And what is the character of the surface, say, half a mile or a mile toward Panama from Obispo?

General DAVIS. From Obispo?

Senator KITTREDGE. Yes.

General DAVIS. That would be the station we call Haute Obispo; it is similar to the ground about Obispo itself. The ground is rising; rising, rising constantly.

Senator KITTREDGE. Is there rock near the surface up there?

General DAVIS. Yes; there is rock near the surface all along there. There is an abundance of rock all along there for some little distance, I think. In fact, all the way from Obispo to Pedro Miguel you may say it is a rock proposition, except the covering of the soil on the surface.

Senator MORGAN. Matachin is about 5 miles, is it, from Gamboa?

General DAVIS. From Gamboa?

Senator MORGAN. Yes.

General DAVIS. Oh, no. Matachin, I should say, was about a mile or a mile and a quarter from Gamboa.

Senator MORGAN. Down the river?

General DAVIS. Down the river.

Senator MORGAN. Yes. Now, what is the general description of the country between Matachin and Gamboa, taking the straight line?

General DAVIS. Very much the same as it is below. It is a rolling ground, and the river is running through a channel the banks of which are 20 or 25 or 30 feet high—cultivated in bananas and corn and other things. It is a rolling, broken surface.

Senator MORGAN. If you should bring your sea-level canal to Matachin, or in that vicinity, and you wished to put in a lock there—

General DAVIS. There is no difficulty in putting in a lock on rock foundation at Matachin.

Senator MORGAN. At Matachin?

General DAVIS. No.

Senator MORGAN. Or anywhere between there and Bohio?

General DAVIS. I would not say anywhere between there and Bohio.

Senator MORGAN. There are lock sites, however?

General DAVIS. There are lock sites at several places—two or three places—between Gamboa and Bohio. One is at San Pablo, a very favorable lock site.

Senator MORGAN. Do you say between Gamboa and Bohio?

General DAVIS. Between Bohio and Gamboa, at several points, there are sites where you could build a lock without any trouble on a rock foundation.

Senator MORGAN. That is what I wanted to get at.

General DAVIS. Oh, yes; you can do it in many places; and San Pablo is a rather favorable place for a lock, too, for the ground is high close by on each side.

Senator MORGAN. On the plan I suggest, there is at present no probability that there is any want of proper lock sites to connect the sea-level with the lock canal?

General DAVIS. Oh, no; oh, no. You can connect it below. You would save money by shortening up your sea-level portion and putting your locks, one, say, at Bohio, and one at San Pablo, and another one at Obispo. If you had three locks, going up to 90 feet, you would save more money that way.

Senator MORGAN. You would not want three locks, though, for 60 feet of elevation?

General DAVIS. Oh, no; of course not.

Senator MORGAN. You would want only two?

General DAVIS. Yes; that is all.

Senator MORGAN. That is all I wanted to ask.

Senator KITTREDGE. What would be the length of the dams at Obispo and the place just south of there toward Panama?

General DAVIS. The dams? There would be no dams required on a 60-foot proposition. The surface of the ground would be higher than the top of your lock.

Senator KITTREDGE. That is the point that I wished to ask about.

General DAVIS. Yes; the surface of the ground would be higher.

Senator MORGAN. No; there is no dam on that site at all.

Senator KITTREDGE. It would be simply the lock structure?

General DAVIS. That is all. Oh, no; there would be no dam there.

Senator KITTREDGE. And would the same condition hold at Pedro Miguel or Miraflores, in that vicinity?

General DAVIS. Not quite, because there is the little river Rio Grande down there to be taken care of; and just so that would be disposed of, which would be a small matter, the conditions would be similar.

Senator KITTREDGE. In that plan or type, I assume that the water from Lake Gamboa would be introduced into the prism of the canal above the locks?

General DAVIS. Exactly.

Senator KITTREDGE. And the water would be used in that event to feed the locks?

General DAVIS. Exactly.

Senator KITTREDGE. Do you think that water supply would be ample for that purpose?

General DAVIS. Oh, abundant. As I showed you yesterday, it is three and a half times greater than the minority proposed for their own lock supply with the Gatun Lake—three and a half times more. Oh, it is an abundance. I have made a calculation that shows that without any question.

Senator MORGAN. If you will allow me to make a suggestion, the plan that I mentioned provides for the same lockage at Pedro Miguel and Miraflores that is provided for by the proposition of the minority with a dam at Gatun, except that there is one lock less.

General DAVIS. Yes; well, they have a summit level of 85 feet, you know.

Senator MORGAN. Yes; with an 85-foot level.

General DAVIS. And you propose 60?

Senator MORGAN. And I propose 60.

General DAVIS. There would be that difference.

Senator MORGAN. There would be that difference?

General DAVIS. Yes; 25 feet taken off of 85.

Senator MORGAN. It would take out one of the locks?

General DAVIS. Yes.

Senator MORGAN. My proposition would require two locks instead of three at that place.

General DAVIS. Yes; I see.

Senator KITTREDGE. What would be the expense of constructing the locks at Obispo and the next lock toward Panama, at Pedro Miguel or Miraflores, or in that vicinity?

General DAVIS. The cost of them?

Senator KITTREDGE. On the plan or type suggested by Senator Morgan in his question?

General DAVIS. That would be a question that I could not answer without careful calculation and study; but those four locks, I suppose, would cost about in proportion as the six were expected to in the 85-foot project—that is, they would be as 4 is to 6—two-thirds; and that amount was \$35,000,000. I suppose it would be two-thirds of the \$35,000,000; something like that. That is as near as I could state it offhand.

Senator KITTREDGE. You stated, in answer to a question by Senator Morgan, that if this is to be a lock canal you preferred the type of lock canal suggested by him to that proposed by the minority.

General DAVIS. I think in general it would be preferable.

Senator KITTREDGE. I wish you would give your reasons for that answer.

General DAVIS. Because it is more readily converted into a sea-level canal; because I think that is the ultimate we are coming to always, and it would be more convertible; that is the reason.

Senator KITTREDGE. What about the safety of the lock structure suggested by Senator Morgan?

General DAVIS. Oh, it would be safe enough. There would be no question of safety. All of his locks would be on solid rock.

Senator KITTREDGE. Would every element of doubt regarding the stability of the lock structure be eliminated?

General DAVIS. Oh, I think so. They would all be on solid rock foundation. It is the 60-foot project the Senator is talking about?

Senator KITTREDGE. Yes.

General DAVIS. Oh, yes; they would all be on rock foundation.

Senator KITTREDGE. How much in excavation would be saved by the plan suggested by Senator Morgan over the sea-level type proposed by the majority of the Board of Consulting Engineers?

General DAVIS. That is a question no one could answer specifically without making some calculations; but there are some guiding points that you can regard. In the lock proposition of the minority they propose to excavate from the Culebra some 53,000,000 yards. For the sea-level proposition there is contained in the Culebra from Obispo to Pedro Miguel 110,000,000 yards. So the difference between those figures represents the earth that would remain, provided the sea-level plan at 85-foot elevation was carried out.

Now, the Senator's proposition is to go down 25 feet deeper; so that if the ratio of the material remaining in the 85-foot project compared to the sea level should be the same for the 60-foot project, then the ratio would be sixty eighty-fifths of the 57,000,000 cubic yards remaining that would come out under the sea-level proposition.

Senator KITTREDGE. Can you give us that figure?

General DAVIS. The stenographer can calculate that in a minute. It is sixty eighty-fifths, twelve-seventeenths. It is an easy enough calculation. [After making calculation.] About 40,000,000 would remain.

Senator KITTREDGE. What unit of cost would be applied for the excavation of that difference?

General DAVIS. Eighty cents to about one-quarter of it, and \$1.25 to the remainder; 80 cents for 10,000,000 yards and about \$1.25 for 30,000,000 yards.

Senator KITTREDGE. And that would be about how much in dollars, about \$50,000,000?

General DAVIS. Fifty-eight millions—that is, if my figures are correct. That is the way it strikes me. No; I am wrong.

Senator KITTREDGE. It would be forty-eight, would it not?

General DAVIS. It would be forty-five millions. But you must remember that out of that mass the lock pits would have to be excavated, which would reduce somewhat that quantity.

Senator KITTREDGE. I think that is all.

Senator MORGAN. General, you have had great experience in the government of these people who have been brought in contact with the Government of the United States at Porto Rico, in Cuba, and in the Philippines. In the Canal Zone you would have, added to the character of the population that you have heretofore governed, a large number of laborers—I mean under the present system of government?

General DAVIS. Yes, sir.

Senator MORGAN. Brought from anywhere you could get them?

General DAVIS. Yes, sir.

Senator MORGAN. Of different nationalities and different habits and different understandings of law and of obedience to law, etc.?

General DAVIS. Yes, sir.

Senator MORGAN. I suppose you will concur with the balance of us in saying that that is a very difficult government to conduct?

General DAVIS. It is a complicated situation; yes, sir.

Senator MORGAN. You have to have laws that in their provisions and in their justice and in the justice of their application would reach from the highest civilization down to what we might call nearly the lowest?

General DAVIS. Of course, the laws should be made to fit all classes.

Senator MORGAN. All classes. The Commission of which you were a member have worked out a system of statutes?

General DAVIS. Yes, sir.

Senator MORGAN. Which is displayed here?

General DAVIS. Yes, sir.

Senator MORGAN. I suppose that that work required a great deal of care and a great deal of reflection in order to make the laws applicable to all the different conditions that you found in the Isthmian Zone?

General DAVIS. Yes, sir; it did.

Senator MORGAN. It was a severe labor?

General DAVIS. I do not know that I would say severe; but it was, of course, burdensome, and there were a good many people assisting in it in their way.

Senator MORGAN. Yes.

General DAVIS. The models which we had to go by were helpful. Americans had had experience in the government of tropical people in the last few years preceding, which experience was useful, and codes had been written; and we found these examples were useful. Some things could be copied out of them.

Senator MORGAN. The models you speak of were such as we had created ourselves in Porto Rico and in Cuba and in the Philippines?

General DAVIS. Yes; in the Philippines and Porto Rico especially. We did not do much legislating in Cuba.

Senator MORGAN. No. You found there a body of Spanish laws—Colombian laws.

General DAVIS. Yes; of Spanish origin.

Senator MORGAN. Of Spanish origin, and modified by some local statutes, I suppose, of Panama?

General DAVIS. Yes, sir. Panama, however, had been in existence so short a while as an independent nation that her legislation was very limited in scope. Most of the legislation that was in existence in Panama was of Colombian origin—at least, of Colombian perfection; of Spanish origin.

Senator MORGAN. And under the directions of the President, supported by the provisions of international law and perhaps by the statutes to some extent, you had to adopt as many of the laws of Colombia as were applicable to the situation and not in conflict with the laws of the United States?

General DAVIS. The President's order, under which he set the government of the Zone on its feet, specified that the laws of the land should prevail until they were changed.

Senator MORGAN. And "the laws of the land" meant the laws of Colombia?

General DAVIS. Yes, sir—until they were changed, or unless they were repugnant to the fundamental principles of our Government.

Senator MORGAN. We have, in the first of our efforts at territorial government, embodiments and displays of what we conceive to be the fundamental principles of our Government?

General DAVIS. Yes, sir.

Senator MORGAN. Involving sometimes trial by jury, and sometimes not?

General DAVIS. Yes, sir.

Senator MORGAN. Involving legislation that takes effect and is operative until it is changed and repealed by Congress, which legislation is by nonelective bodies, bodies appointed by the President of the United States, and sometimes two bodies—one appointed and the other elected?

General DAVIS. Exactly.

Senator MORGAN. And they went on under the provisions of the general system of government in the United States and of the Constitution of the United States to formulate laws that those people were compelled to obey as this territorial system sprang up?

General DAVIS. Yes, sir.

Senator MORGAN. There seems to have been no effort at all made at the establishment of a territorial system of government in the Zone as far as we have gone. It is a system such as was established or supposed to have been established for the government of the Ter-

ritory of Louisiana after its acquisition under the treaty with France, and before Congress took hold of it to enact laws which should operate directly through the force of the Congressional action. Have you attempted at all to establish jury trial in the Zone?

General DAVIS. No, sir. It was attempted in Porto Rico; it is authorized by the statute, but the Porto Ricans make very little use of it—very little use of it.

Senator MORGAN. Have you attempted to establish there, practically or otherwise, by your declaration as legislators, the writ of habeas corpus or anything corresponding to it?

General DAVIS. The privileges of the writ are provided for, I think, in the criminal code which was enacted by the Commission, and which is one of the acts that has been printed in the annual report of the Commission. The provision of law applying to Porto Rico was, I have been told by the draftsmen of that law, taken principally as a model. I refer to Judge Magoon, the present governor of the Zone, who was the draftsman of the present criminal code for the Canal Zone.

Senator MORGAN. He was then general counsel for the Isthmian Canal Commission?

General DAVIS. Yes, sir.

Senator MORGAN. And was acting in that capacity in the drafting of that code?

General DAVIS. Yes, sir.

Senator MORGAN. All of which underwent the supervision and examination of the Commission?

General DAVIS. Oh, yes, sir; it was all enacted by the Commission afterwards.

Senator MORGAN. You established courts in that code?

General DAVIS. Yes, sir; under that code there were courts established.

Senator MORGAN. You established an appellate court?

General DAVIS. Yes; a court with three judges was created, and these three judges, meeting together, were granted appellate powers.

Senator MORGAN. These three judges were called district judges or circuit judges?

General DAVIS. I have forgotten exactly the term used to describe them, but they were each assigned to a special, separate district.

Senator MORGAN. They were courts of original jurisdiction?

General DAVIS. Yes, sir.

Senator MORGAN. That tried cases and then sat in banc and heard the cases on appeal?

General DAVIS. Exactly; that is right.

Senator MORGAN. Was any attempt made, or has any attempt been made, either by Congress or otherwise, to give appellate jurisdiction or supervision to the Federal courts of the United States over that isthmian canal?

General DAVIS. I think attempts have been made, and I am not quite familiar with the legislative history of those attempts, but I have the impression that a member of this committee offered a bill in the Senate which was actually passed through the Senate and came into conference, but I believe it was not finally enacted into law.

Senator MORGAN. I do not remember that any law was enacted on that subject.

General DAVIS. No; I think there was none enacted, but you asked me if attempts were made.

Senator MORGAN. Yes; I know that.

(The committee thereupon took a recess until 2 o'clock p. m.)

AFTERNOON SESSION.

The committee met at 2 o'clock p. m., pursuant to the taking of recess.

**STATEMENT OF MAJ. GEN. GEORGE W. DAVIS, U. S. ARMY
(RETIRED)—Continued.**

Senator Morgan submitted a copy of a letter from the President to the Secretary of War, dated May 9, 1904, and asked that it be made a part of the record, which was ordered.

The letter is as follows:

WHITE HOUSE,
Washington, D. C., May 9, 1904.

SIR: By the act of Congress approved June 28, 1902, the President of the United States is authorized to acquire for and on behalf of the United States all the rights, privileges, franchises, concessions, grants of lands, rights of way, unfinished work, plants, shares of the capital stock of the Panama Railway, owned by or held for the use of the New Panama Canal Company, and any other property, real, personal, and mixed, of any name or nature, owned by the said New Panama Canal Company, situated on the Isthmus of Panama. The President is by the same act also authorized to acquire for and on behalf of the United States perpetual control of a strip of land on the Isthmus of Panama, not less than 6 miles in width, extending from the Caribbean Sea to the Pacific Ocean, and the right to excavate, construct, and maintain perpetually, operate and protect thereon, a ship canal of certain specified capacity, and also the right to perpetually operate the Panama Railroad. Having acquired such rights, franchises, property, and control, the President is by the same act required to excavate, construct, and complete a ship canal from the Caribbean Sea to the Pacific Ocean, and to enable him to carry forward and complete this work he is authorized to appoint, by and with the consent of the Senate, an Isthmian Canal Commission of seven members, who are to be in all matters subject to his direction and control.

By the terms of the canal convention between the United States and the Republic of Panama, entered into in pursuance of the said act of Congress approved June 28, 1902, the ratifications of which were exchanged on the 26th day of February, 1904, the Republic of Panama granted to the United States—

First, the perpetual use, occupation, and control of a certain zone of land, land under water, including islands within said zone, at the Isthmus of Panama, all to be utilized in the construction, maintenance, and operation, sanitation and protection of the ship canal, of the width of 10 miles, extending to the distance of 5 miles on each side of the central line of the route of the canal, and the use, occupation, and control of other lands and waters outside of the zone above described

which may be necessary and convenient for the construction, maintenance, operation, sanitation, and protection of said canal or any auxiliary canals or other works necessary and convenient for the same purpose; also the islands of Perico, Naos, Culebra, and Flamenco, situated in the Bay of Panama; and,

Second, all the rights, powers, and authority within the zone, auxiliary lands and lands under water, which the United States would possess and exercise if it were the sovereign of the territory granted, to the entire exclusion of the exercise by the Republic of Panama of any such sovereign rights, power, and authority.

By the act of Congress approved April 28, 1904, the President is authorized, upon acquisition of the property of the New Panama Canal Company, and the payment to the Republic of Panama of the price for compensation agreed upon in the said canal convention, to take possession of and occupy on behalf of the United States the zone of land and land under water, including islands within said zone, at the Isthmus of Panama, of the width of 10 miles, extending to the distance of 5 miles on each side of the central line of the route of the canal to be constructed thereon, including the islands of Perico, Naos, Culebra, and Flamenco, and from time to time, as may be necessary and convenient, certain auxiliary lands and waters outside the said zone for the purpose of constructing, maintaining, operating, sanitating, and protecting the ship canal, the use, occupation, and control whereof were granted to the United States by the Republic of Panama in the said canal convention.

By the same act the President is authorized, for the purpose of providing temporarily for the maintenance of order in the Canal Zone and for maintaining and protecting the inhabitants thereof in the free enjoyment of their liberty, property, and religion, to delegate to such person or persons as he may designate and to control the manner of their exercise, all the military, civil, and judicial powers as well as the power to make all needful rules and regulations for the government of the Canal Zone and all the rights, powers, and authority granted by the said canal convention to the United States, until the close of the Fifty-eighth Congress.

Payments of the authorized purchase price of \$40,000,000 to the New Panama Canal Company for the property of that corporation on the Isthmus, including the share of railway stock, and for the records in Paris, and of the sum of \$10,000,000, as stipulated in the canal convention, to the Republic of Panama for the rights, powers, and privileges granted to the United States by the terms of the said convention have been made and proper instruments of transfer have been executed by the Panama Canal Company. The members of the Isthmian Canal Commission have been appointed. They have organized the Commission and entered upon their duties. I have taken possession of and now occupy, on behalf of the United States, the Canal Zone and public land ceded by the Republic of Panama.

It becomes my duty, under the statutes above referred to, to secure the active prosecution of the work of construction of the canal and its auxiliary works, through the Isthmian Canal Commission, and in connection with such work and in aid thereof to organize and conduct a temporary government of the Zone, so as to maintain and protect the inhabitants thereof in the free enjoyment of their liberty, property, and religion.

Inasmuch as it is impracticable for the President, with his other public duties, to give to the work of supervising the Commission's construction of the canal and government of the Zone the personal attention which seems proper and necessary, and inasmuch as the War Department is the Department which has always supervised the construction of the great civil works for improving the rivers and harbors of the country and the extended military works of public defense, and as the said Department has from time to time been charged with the supervision of the government of all the island possessions of the United States, and continues to supervise the government of the Philippine Islands, I direct that all the work of the Commission done by virtue of powers vested in me by the act of Congress approved June 28, 1902, in the digging, construction, and completion of the canal, and all the governmental power in and over said Canal Zone and its appurtenant territory which, by virtue of the act of Congress approved April 28, 1904, and these instructions, shall be vested in said Isthmian Canal Commission, shall be carried on or exercised under your supervision and direction as Secretary of War.

Subject to the limitations of law and the conditions herein contained, the Isthmian Canal Commission are authorized and directed—

1. To make all needful rules and regulations for the government of the Zone and for the correct administration of the military, civil, and judicial affairs of its possessions until the close of the Fifty-eighth Congress.

2. To establish a civil service for the government of the strip and construction of the canal, appointments to which shall be secured as nearly as practicable by a merit system.

3. To make or cause to be made all needful surveys, borings, designs, plans, and specifications of the engineering, hydraulic, and sanitary works required, and to supervise the execution of the same.

4. To make and cause to be executed, after due advertisement, all necessary contracts for any and all kinds of engineering and construction works.

5. To acquire by purchase or through proper and uniform expropriation proceedings, to be prescribed by the Commission, any private lands or other real property whose ownership by the United States is essential to the excavation and completion of the canal.

6. To make all needful rules and regulations respecting an economical and correct disbursement and an accounting for all funds that may be appropriated by Congress for the construction of the canal, its auxiliary works, and the government of the Canal Zone, and also to establish a proper and comprehensive system of bookkeeping, showing the state of the work, the expenditures by classes, and the amounts still available.

7. To make requisition on the Secretary of War for funds needed from time to time in the proper prosecution of the work, and to designate the disbursing officers authorized to receipt for the same.

The inhabitants of the Isthmian Canal Zone are entitled to security in their persons, property, and religion and in all their private rights and relations. They should be so informed by public announcement. The people should be disturbed as little as possible in their customs and avocations that are in harmony with principles of well-ordered and decent living.

The municipal laws of the Canal Zone are to be administered by the ordinary tribunals substantially as they were before the change. Police magistrates and justices of the peace and other officers discharging duties usually devolving upon these officers of the law will be continued in office if they are suitable persons. The governor of the Zone, subject to approval of the Commission, is authorized to appoint temporarily a judge for the Canal Zone, who shall have the authority equivalent to that usually exercised in Latin countries by a judge of a court of first instance; but the Isthmian Canal Commission shall fix his salary and may legislate respecting his powers and authority, increasing or diminishing them in their discretion, and also making provision for additional or appellate judges should the public interest require.

The laws of the land, with which the inhabitants are familiar, and which were in force on February 26, 1904, will continue in force in the Canal Zone and in other places on the Isthmus over which the United States has jurisdiction until altered or annulled by the said Commission, but there are certain great principles of government which have been made the basis of an existence as a nation which we deem essential to the rule of law and the maintenance of order, and which shall have force in said Zone. The principles referred to may be generally stated as follows:

That no person shall be deprived of life, liberty, or property without due process of law; that private property shall not be taken for public use without just compensation; that in all criminal prosecutions the accused shall enjoy the right of a speedy and public trial, to be informed of the nature and cause of the accusation, to be confronted with the witnesses against him, to have compulsory process for obtaining witnesses in his favor, and to have the assistance of counsel for his defense; that excessive bail shall not be required nor excessive fines imposed, nor cruel or unusual punishment inflicted; that no person shall be put twice in jeopardy for the same offense, or be compelled in any criminal case to be a witness against himself; that the right to be secure against unreasonable searches and seizures shall not be violated; that neither slavery nor involuntary servitude shall exist except as a punishment for crime; that no bill of attainder or ex post facto law shall be passed; that no law shall be passed abridging the freedom of speech or of the press, or of the rights of the people to peaceably assemble and petition the government for a redress of grievances; that no law shall be made respecting the establishment of religion or prohibiting the free exercise thereof: *Provided, however,* That the Commission shall have power to exclude from time to time from the Canal Zone and other places on the Isthmus, over which the United States has jurisdiction, persons of the following classes who were not actually domiciled within the Zone on the 26th day of February, 1904, viz: Idiots, the insane, epileptics, paupers, criminals, professional beggars, persons afflicted with loathsome or dangerous contagious diseases; those who have been convicted of felony, anarchists, those whose purpose it is to incite insurrection, and others whose presence it is believed by the Commission would tend to create public disorder, endanger the public health, or in any manner impede the prosecution of the work of opening the canal; and may cause any and all such newly arrived persons or those alien to the Zone to be expelled and

deported from the territory controlled by the United States, and the Commission may defray from the canal appropriation the cost of such deportation as necessary expenses of the sanitation, the police protection of the canal route, and the preservation of good order among the inhabitants.

The Commission may legislate on all rightful subjects of legislation not inconsistent with the laws and treaties of the United States so far as they apply to said Zone and other places, and the said power shall include the enactment of the sanitary ordinances of a preventive or curative character to be enforced in the cities of Colon and Panama, and which are contemplated and authorized by article 7 of said canal convention. Such legislative power shall also include the power to raise and appropriate revenues in said Zone; and all taxes, judicial fines, customs duties, and other revenues levied and collected in said Zone by or under the authority of said Commission shall be retained, accounted for, and disbursed by said Commission for its proper purposes.

The members of said Commission to the number of four or more shall constitute a legislative quorum, and all rules and regulations passed and enacted by said Commission shall have set forth as a caption that they are enacted by the Isthmian Canal Commission "By authority of the President of the United States."

The Commission shall hold its regular quarterly meetings at the office of the Commission either in Panama or at a branch office in Washington, and special meetings may be held at the pleasure of the Commission.

All laws, rules, and regulations of a governmental character enacted by the Commission hereunder shall be submitted to you for your approval, and should your approval be withheld from any such law, rule, or regulation, then from that time the law, rule, or regulation shall thereafter have no force or effect.

Maj. Gen. George W. Davis, U. S. Army (retired), a member of the Canal Commission, is hereby appointed governor of the Isthmian Canal Zone. He will proceed at once to the Isthmus of Panama. He will in my name, as the chief executive in the Canal Zone, for and on behalf of the United States, see that the laws are faithfully executed and will maintain possession of said territory, including the public lands therein and the property, real and movable, on the Isthmus of Panama, except that of the Panama Railroad, that has recently been acquired from the Republic of Panama. He is hereby vested with the power to grant reprieves and pardons for offenses against the rules, regulations, and laws in force by virtue of action of the Commission or by virtue of the clause hereof continuing in force the laws of Panama. In case of his disability or absence from the Canal Zone at any time, the Isthmian Canal Commission is empowered to designate the person or persons to act as governor during such absence or disability. Except as herein prescribed, the duties of the governor shall be fixed by legislation of the Canal Commission.

For the preservation of order and protecting the property of the United States within or without said Zone, as provided by article 7 of the canal convention, an adequate police force shall be maintained. If at any time there shall arise necessity for military or naval assistance the governor shall, if possible, promptly notify you, and in the

event of a sudden exigency the governor may call upon any available military or naval force of the United States to render assistance, and the same shall be immediately furnished.

It is a matter of first importance that the most approved and effective methods and measures known to sanitary science be adopted in order that the health conditions on the Isthmus may be improved. It is the belief of those who have noted the successful results secured by our Army in Cuba in the obliteration of yellow fever in that island that it is entirely feasible to banish the diseases that have heretofore caused most mortality on the Isthmus, or at least to improve as greatly the health conditions there as in Cuba and Porto Rico. I desire that every possible effort be made to protect our officers and workmen from the dangers of tropical and other diseases, which in the past have been so prevalent and destructive in Panama.

Rear-Admiral John G. Walker, U. S. Navy (retired), and Col. Frank J. Hecker, members of the Isthmian Canal Commission, are hereby designated as members of the joint commission provided for by articles 6 and 15 of the canal convention. The moiety of the necessary expenses of the commission to be created in pursuance of articles 6 and 15 of the above-cited canal convention will be defrayed from the appropriation applicable to the ship canal to connect the waters of the Atlantic and Pacific oceans.

The Isthmian Canal Commission will prepare for Congress and place in your hands on or before December 1 of each year a full and complete report of all their acts and of the operations conducted by them in respect to the canal construction and the government of the Canal Zone. These reports will contain a detailed account of all moneys received and disbursed in the performance of their duties and of the progress made in the construction of the canal.

The necessary expenses incurred by the Commission in carrying on the government of the Canal Zone will be defrayed from the local revenues so far as the said revenues may be sufficient, and the remainder will be met from the appropriation made by the fifth section of the act of Congress, approved June 28, 1902. An estimate of the proposed expenditures and revenues for each year in carrying on the government of the Zone will be submitted to Congress at the beginning of each annual session.

By virtue of the ownership by the United States of about sixty-nine seventieths of the shares of the capital stock of the Panama Railroad, the general policy of the managers of said road will be controlled by the United States. As soon as practicable I desire that all the members of the Isthmian Canal Commission be elected to the board of directors of the road, and that the policy of the road be completely harmonized with the policy of the Government of making it an adjunct to the construction of the canal, at the same time fulfilling the purpose for which it was constructed as a route of commercial movement across the Isthmus of Panama. If any contracts or other obligations now subsist between the railway company and other transportation companies that are not in accord with sound public policy, then such contracts must be terminated as soon as it is possible to effect that object.

No salary or per diem allowance of compensation in addition to the stated salary and per diem allowance of the members of the Isthmian Canal Commission will be allowed to any member of the Commission by reason of his services in connection with the civil government of

the Canal Zone, or his membership of any board or commission concerned in or connected with the construction of the canal, or by reason of his services as an officer or director of the Panama Railroad.

If there now be in force within the Canal Zone any franchise granting to any person or persons a privilege to maintain lotteries or hold lottery drawings or other gambling methods and devices of a character forbidden by the laws of the United States, or if the grantee of any such privilege has now the right to sell lottery tickets or similar devices to facilitate the business of the concessionaire, the Commission shall enact laws annulling the privileges or concessions and punishing future exercise of the same by imprisonment or fine or both.

These instructions may be modified and supplemented as occasion shall arise.

Very respectfully,

THEODORE ROOSEVELT.

Hon. WILLIAM H. TAFT,
Secretary of War.

Senator MORGAN. When this Commission took charge of the work there—the Canal Zone—and you took charge as governor, there were a number of citizens of Panama or Colombia—former citizens of Colombia, but then citizens of Panama—who resided within the Zone?

General DAVIS. Yes, sir.

Senator MORGAN. Including the inhabitants both of Colon and Panama, who were subject to your powers as governor and the powers of the Commission in certain particulars that are defined in the Hay-Varilla treaty?

General DAVIS. Yes.

Senator MORGAN. The citizenship of none of those people has been changed by any law of the United States or act of the Commission?

General DAVIS. None that I know of.

Senator MORGAN. The citizens of the United States who have gone there have not forfeited their citizenship here as far as you know?

General DAVIS. No.

Senator MORGAN. Retaining their citizenship they have gone there to transact whatever business they chose to embark in?

General DAVIS. Yes.

Senator MORGAN. That number, besides the employees of the Canal Commission and the railroad, I suppose, is very small?

General DAVIS. Outside of the Commission and the railroads, you say?

Senator MORGAN. Yes.

General DAVIS. Those are few; yes, there are a few merchants—a few individuals who are engaged in business there.

Senator MORGAN. In Colon or Panama or in the Zone?

General DAVIS. Along the Zone also; all three.

Senator MORGAN. But the relative rights and duties and obligations of citizenship have not been changed by any act of which you are aware?

General DAVIS. Not by any act of which I am aware, unless the act of passing out of the specific jurisdiction of the United States by those individuals has affected their status.

Senator MORGAN. When you call it specific jurisdiction of the United States you are going into a classification of the jurisdiction of the

United States, but they pass from one to another; they are entirely under the United States?

General DAVIS. Yes, sir.

Senator MORGAN. You consider the flag of the United States as being entirely at home in the Zone?

General DAVIS. Yes; I consider it is entirely at home there, but whether or not technically we have a right to fly the flag of the United States in the Zone—I say technically—it seems to me might be questionable, possibly.

Senator MORGAN. Have you ever raised one?

General DAVIS. No; and it never will be raised, I think; but since titular sovereignty resides in Panama, I think that proposition has been stated many times——

Senator MORGAN. Unless you can define the word “titular” I do not think I could accept the fact.

General DAVIS. Well, the Hay-Varilla treaty recognizes some shadow of what is called sovereignty as still remaining in the Panama Zone.

Senator MORGAN. As that is a matter of some importance in connection with the question I desire to propound to you I wish to refer you to that treaty for a moment.

General DAVIS. I am not an international lawyer or a lawyer of any kind.

Senator MORGAN. No; but I want to get it in the record, so that men who are lawyers and men who are laymen—there are a great many laymen in Congress, you know—can have some understanding of exactly what we are trying to get at and what the definitions are.

The CHAIRMAN. General, I understand you that the American flag was never floated on the Zone?

General DAVIS. No, sir; that is a mistake. I raised it myself, and I would not have tolerated for an instant the idea that I could not raise it.

The CHAIRMAN. I understood it the other way.

General DAVIS. But I think technically a question might be raised as to the assumption by the United States of every sovereign function, and since the flag seems to be an emblem of sovereignty I merely suggest the question as one that may possibly have two answers.

Senator MORGAN. The article of the Hay-Varilla treaty of February 26, 1904, which is the date of its ratification, reads as follows:

“The Republic of Panama grants to the United States all the rights, power, and authority within the Zone mentioned and described in Article II of this agreement and within the limits of all auxiliary lands and waters mentioned and described in said Article II which the United States would possess and exercise if it were the sovereign of the territory within which such lands and waters are located, to the entire exclusion of the exercise by the Republic of Panama of any such sovereign rights, power, or authority.”

It looks to me like it is putting it both ways; that there is not only an affirmation of absolute sovereignty over all these things in that Zone, but there is an express exclusion of any sovereign rights of Panama, so that the titular sovereignty that the General mentions, I suppose, refers to the fact that Panama has lands lying above and lands lying below the Canal Zone and along the borders of the Canal Zone, and that she has the right to extend her authority from one place to another, notwithstanding the interposition of the Canal Zone.

Now, do you understand that Panama has the right to hold any election in the Zone?

General DAVIS. No; and never attempted to.

Senator MORGAN. And if attempted it would be stopped?

General DAVIS. It would be stopped, I am quite sure; it would have been during my time and I presume it would be now.

Senator MORGAN. It is a land of laws in which the people are supposed to be sovereign; it is a republic?

General DAVIS. Yes.

Senator MORGAN. And it has citizens residing there within the Zone who have the right to vote outside the Zone, but not within it?

General DAVIS. Yes.

Senator MORGAN. Now, I assume in the questions I will ask you that that zone is within the absolute sovereign authority of the United States Government for all purposes of government. If there are any trusts connected with it that we are bound to execute, that is a different question; but the right is within us. Now, in virtue of that duty, which is recited in the directions of the President to Secretary Taft, which has been read and inserted in the report, I find certain provisions that I wish to call attention to.

In the seventh section or paragraph of the letter I find the following. This seems to be a bill of rights or restrictions upon the power of the isthmian canal government.

"That no person shall be deprived of life, liberty, or property without due process of law; that private property shall not be taken for public use without just compensation; that in all criminal prosecutions the accused shall enjoy the right of a speedy and public trial, to be informed of the nature and cause of the accusation, to be confronted with the witnesses against him, to have compulsory process for obtaining witnesses in his favor, and to have the assistance of counsel for his defense; that excessive bail shall not be required nor excessive fines imposed, nor cruel or unusual punishment inflicted; that no person shall be put twice in jeopardy for the same offense, or be compelled in any criminal case to be a witness against himself; that the right to be secure against unreasonable searches and seizures shall not be violated; that neither slavery nor involuntary servitude shall exist except as a punishment for crime; that no bill of attainder or ex post facto law shall be passed; that no law shall be passed abridging the freedom of speech or of the press, or of the rights of the people to peaceably assemble and petition the Government for a redress of grievances; that no law shall be made respecting the establishment of religion or prohibiting the free exercise thereof."

Those provisions seem to be restraints or prohibitions or limitations against the exercise of power on the part of the Commission, but they do not in terms, and perhaps not in intention, confer upon individuals who may be inhabitants of that zone the rights which are said to be protected here against invasion by the Commission. The important part of this matter that I would call your special attention to now is contained in the proviso:

"*Provided, however,* That the Commission shall have power to exclude from time to time from the Canal Zone and other places on the Isthmus, over which the United States has jurisdiction, persons of the following classes who were not actually domiciled within the Zone on the 26th day of February, 1904, viz: Idiots, the insane, epileptics

paupers, criminals, professional beggars, persons afflicted with loathsome or dangerous contagious diseases; those who have been convicted of felony, anarchists, those whose purpose it is to incite insurrection, and others whose presence it is believed by the Commission would tend to create public disorder, endanger the public health, or in any manner impede the prosecution of the work of opening the canal, and may cause any and all such newly arrived persons or those alien to the Zone to be expelled and deported from the territory controlled by the United States, and the Commission may defray from the canal appropriation the cost of such deportation as necessary expenses of the sanitation, the police protection of the canal route, and the preservation of good order among the inhabitants."

Has it ever occurred in your administration that you have found it necessary to exercise this power?

General DAVIS. Several times, sir.

Senator MORGAN. It is hardly worth while to give cases, but what would be the nature of such a case?

General DAVIS. I could not remember names and I could scarcely remember dates with any precision; but I think a few individuals of those classes which sometimes arrive at our immigration stations in the United States from foreign countries and in whose respect the conditions were not fulfilled—that is to say, ones such as are described in that mandate of the President—were informed that they could get out of the Zone or be deported.

In one case, I think I can remember one case where a man was put on board a steamer and sent out of the Zone, and the Commission paid the fare of that man to get rid of him. I can not remember whether he was a gambler or whether he was a crook, but he was some sort of an individual of that kind as I recall it; I can not remember the exact facts in connection with it. I think Governor Magoon has made use of that authority several times since he assumed the government.

Senator MORGAN. In the instances you refer to where you exercise the authority was it done by the vote of the Commission?

General DAVIS. No, sir; it was done as an executive act, the governor being charged with the execution of the laws, and this being one of the laws that were to be executed. I considered this order of the President as legislation, and acting within the provisions of that law and as a representative of the Commission I executed the law.

Senator MORGAN. Now, we may all assume, for there will be no disputation about the point at all, that there is no State or Territory in the Union, on the continent here or under our control, where the governor of such State or Territory, or any other power of the United States, has the right of banishment.

General DAVIS. No, sir.

Senator MORGAN. This is the only case in which it exists?

General DAVIS. The only one that I know of.

Senator MORGAN. Is that an important power to be exercised there?

General DAVIS. I think it ought to be retained by all means.

Senator MORGAN. Now, General, in time of peace that power could not be exercised by any judicial or executive tribunal in the United States except within a territory or zone that was placed under military law, being made a military reservation; so that if you would undertake to exercise this authority anywhere in that zone or anywhere else under the laws of the United States or any other laws you must apply

to the situation, as I understand it, the laws of military power just as they apply to a military reservation in the United States.

Senator HOPKINS. Would not that depend upon the question as to whether the Constitution of the United States extends over that territory? If it does not, then there is no legal objection to a civil officer exercising power of that kind.

Senator MORGAN. The Constitution of the United States, in my judgment, is overwhelming in its application to all situations, both of war and of peace. A state of peace in a country invokes and puts in operation the laws of peace; a state of war puts in operation the laws of war; but we have a further provision of the Constitution upon which is predicated the right to establish rules and regulations for the government of the Army and the militia, which has always been applied, and I think with entire sanction of all authority—the Supreme Court and all other authorities—to any reservation set apart for military purposes, although the country may be in a state of peace.

We have here now, as I understand it, many military reservations in the United States where there exist provost courts for the administration of the civil law within the reservation, at the same time the predominant, the paramount law is military; and at military posts and forts, or any such place—an arsenal, for instance—the commandant has the right to exercise military power for the purpose of maintaining peace and order and preventing any of these things that are suggested by this letter of the President to Secretary Taft, and that is perfectly constitutional, as I understand it, and legitimate, and is according to the settled and uniform practice of the Government of the United States.

The point I make about it is this: That this power can not be retained in any place over which the United States has jurisdiction except that place is under military regimen. If you put it under military regimen the power is perfectly legitimate; if you take it out of that regimen it is unconstitutional, and would not be enforced by any official, executive or judicial, in any of the States, or by the Federal Government.

Now, in organizing the civil courts in the Zone, you have conferred upon them the power to issue all the rights that belong to courts?

General DAVIS. Yes.

Senator MORGAN. Writs of habeas corpus?

General DAVIS. Yes.

Senator MORGAN. And writs of execution, and so forth?

General DAVIS. Yes, sir.

Senator MORGAN. Even to the extent of taking a man's life by hanging?

General DAVIS. I can not remember what the punishment is for the capital offense, but it is according to the code, and the code is printed here in one of the books. I never had occasion to carry out the law in a capital case.

Senator MORGAN. You have established a penitentiary there?

General DAVIS. We have established a place called the penitentiary; it is a lockup.

Senator MORGAN. That is a penitentiary?

General DAVIS. Yes.

Senator MORGAN. And there are numerous convicts there?

General DAVIS. Yes.

Senator MORGAN. And have been heretofore?

General DAVIS. Yes.

Senator MORGAN. Convicted of various offenses which are punishable by the statutes of the Zone?

General DAVIS. Yes.

Senator MORGAN. Punishment by confinement and hard labor?

General DAVIS. Yes, sir.

Senator MORGAN. Now the power to pardon has also been exercised by the governor.

General DAVIS. And delegated to him by the order of the President.

Senator MORGAN. Yes; delegated to him by the order of the President.

General DAVIS. Yes, sir.

Senator MORGAN. So that there is a certain delegation of civil power there which is exercised in harmony with this power of punishment?

General DAVIS. Yes, sir.

Senator MORGAN. Under the same code and same letter?

General DAVIS. Yes, sir.

Senator MORGAN. Yes. Inasmuch as such powers under the Constitution of the United States and under the form of our government can not be exercised at least toward citizens of the United States and can not be exercised, indeed, toward any persons except through the military arm of the government, is it not logical and do you not think it is our duty to declare that the government of that Zone shall be a government of a military reservation?

General DAVIS. Well, Senator, in your long question, or the prelude to it, you made a statement that provost courts were invoked or that they were used to carry on government within a military reservation, and, as I understood you to say, in time of peace?

Senator MORGAN. Yes.

General DAVIS. That is hardly a fact. The provost court is an instrumentality, the will of the commanding general, exercised only in time of war. I have used that in time of war, but never in time of peace; nor have I ever seen a case where the provost court, so called—that is to say, a military officer or a group of military officers sitting as a tribunal with military bailiffs and military attachés—has ever sat in time of peace; I have never seen it.

Senator MORGAN. Your experience has not been so extensive as mine. After peace was proclaimed in the South, and ratified in every possible form, the provost courts down there continued to perform their functions.

General DAVIS. That was a military occupation that followed the conflict.

Senator MORGAN. Yes; a military occupation is the very point I am going on. I insist that we ought to characterize the occupation of the Canal Zone by the United States as a military occupation, not a civil occupation merely; not for the purposes of ordinary civil government, but a military occupation, so that this order of the President can be justified—which is exactly right; and all of these other laws should be justified where the writ of habeas corpus is within reach of the governing power, the judicial power, or the governing power, and its suspension may be lawfully made without the order of the President of the United States or by any act of Congress.

What I am trying to do is to get this judicial system in the Zone in

something like a logical arrangement, comporting with the principles of the United States which are declared here in the bill of rights, and I understand you to say that you do not think it would be safe to dispense with this right of banishment?

General DAVIS. No; but I call it eviction; it may be the same thing.

Senator MORGAN. Yes; eviction is about the softest word that I have heard applied to it.

Senator DRYDEN. I suppose the man that is put out doesn't know the difference.

Senator MORGAN. And it extends to all classes of people without reference to citizenship, except the individuals that were there before a certain date?

General DAVIS. Yes.

Senator MORGAN. They are exempt?

General DAVIS. Yes.

Senator MORGAN. American citizens are not exempt?

General DAVIS. You mean American citizens who were there anterior to this date?

Senator MORGAN. No; citizens who have come there since then.

General DAVIS. No, sir; they are not.

Senator MORGAN. Taking an employee of the Government who may be a man getting \$3,000 or \$5,000 a year, who becomes a nuisance and a danger to the work we are carrying on there, this order gives you the power to banish him?

General DAVIS. Yes.

Senator MORGAN. Well, that power doesn't belong to any other official in the United States or scarcely in the world. At the same time it is legitimate, provided you put the character of the government upon the right footing, say in your law that this is a military reservation, and then the power comes from that fact, it is a military power exercised in a discretionary way, and the officer is protected. I think that one of the provisions in that law must have been suggested to the President's mind by the fact that certain aggregations or combinations or associations of laborers have grown up in the United States, and pretty much all over the world, which might be very disadvantageous in the canal.

General DAVIS. Of course I can not say what may have actuated him in putting that language in the order. I do not imagine that he thinks the ordinary trades union as it is formed throughout the country would necessarily be a dangerous element. I do not think that that could have been in his mind, although of course I don't know about it.

Senator MORGAN. Suppose some man, black or white or yellow or red—for you have all the complexions there that nature knows about—should come into that Zone for the purpose of organizing a strike among the laborers; would you be authorized to banish him under this law?

General DAVIS. I should think the authority would be sufficient to send him away; yes.

Senator MORGAN. And don't you think the necessity would be extreme that he should be banished?

General DAVIS. I know cases of labor agitators in Porto Rico that were evicted under Spain, and I think ought to be evicted now at any time, and it would be a wise act to do it, in my opinion.

Senator MORGAN. The power to evict a man who may interrupt labor there in any way, and particularly a man who may do it for the purpose of getting up great demonstrations on the part of labor, is certainly a power that the government of the Zone ought to possess. You could not very well get along without it in a mixed community like that, and they are very liable there to have agitations, I suppose?

General DAVIS. I think so; I think we are bound to have them.

Senator MORGAN. And with the negro there that is not abstemious—

General DAVIS. In the way of intoxicating liquors?

Senator MORGAN. Yes.

General DAVIS. I must say this for the Jamaica negro: That he is not a cantankerous individual; he is not a quarrelsome person at all; he is not a drunkard. While I was on the Isthmus I did not see two Jamaica negroes who were drunk.

Senator MORGAN. You do not know about the Spaniards that came from northern Spain, about a thousand of them; how they have worked?

General DAVIS. They came over recently?

Senator MORGAN. Yes.

General DAVIS. The men that live on the shores of the Bay of Biscay—the north of Spain men—are excellent men.

Senator MORGAN. But meddlesome and high tempered?

General DAVIS. Not specially so. Those north of Spain men are excellent laborers.

Senator DRYDEN. If Senator Morgan will allow me to interrupt him, I wish General Davis would state what are the weaknesses of the West Indian negro.

General DAVIS. Laziness.

Senator DRYDEN. That is about all?

General DAVIS. He is not malicious or vicious. There is more or less petty thievery going on among them, but highway robbery and murder are very rare, much more rare than they are among our southern negroes, I think, from my observation.

Senator DRYDEN. They do not think it wrong, I suppose, to pilfer a little?

General DAVIS. I do not believe they do; it is sort of a transfer of possessions which does not mean much to them.

Senator MORGAN. Another reason that suggested itself to my mind, General—and I wish to know whether you concur or not—for making a military zone of this area is the possible danger of riots or belligerent operations among the employees and the like of that that might occur in the Zone or that might occur among the Panamanians in Colon and Panama.

General DAVIS. Yes, sir; of course it goes without saying that the Zone is not and never can be a settled community; that would be an impossibility. Its inhabitants are, you might say, exotic; they are only there for a limited period, and as soon as they get through with what they are there for they leave. Of course a settled community, where the inhabitants have been born there and raised there and lived there all their lives and expect to die there, is one proposition; but with a community such as will exist at Panama, as does exist to-day and will exist until the canal is finished, there is no such thing as public sentiment. That public sentiment is our safety, our balance wheel all over our country—

Senator MORGAN. At home, yes.

General DAVIS. But public sentiment has no force on the Isthmus that I could discover.

Senator MORGAN. Is there any authority that you know of that is more respected by the people of all classes you have mentioned and that we know are there than the military authority?

General DAVIS. There is a very definite, positive respect paid to either an exercise of force or a visible power to exercise it.

Senator MORGAN. They have been raised that way?

General DAVIS. Born and grown up to it; yes.

Senator MORGAN. So it would be very difficult to control them by ordinary civil process, such as arrest and imprisonment in a jail or penitentiary?

General DAVIS. I think that a force should be available, so that in case there was a disposition to disregard the exercise of the ordinary police agencies of the country a stronger force could be invoked, but I doubt very much that it would be necessary to use it. I think the presence of it would serve the purpose.

Senator MORGAN. That is, the presence of the power would dispense with the necessity of using it?

General DAVIS. Yes.

Senator MORGAN. But I was considering it now as a form of government, with the view of impressing the sense of authority of the United over everybody in that Zone, whether it is not stronger and easier to execute, and less dangerous to the individual people who are controlled in that way, if it appears in military form than in the form of the administration of justice on benches and in courts?

General DAVIS. Well, is that a question?

Senator MORGAN. Yes.

(The stenographer repeated the question.)

General DAVIS. The simpler the government the better, and I suppose a benevolent despotism is the only really perfect government that has been conceived by man. But the simpler this government the better, and if the people of the United States through their representatives in Congress are willing to delegate that power to the governor of the Zone or to the President, so that he may name a governor of the Zone with those attributes, I should say it would be very desirable. But I have always had some doubt as to the willingness of the people of the United States to delegate such power to anybody, I have always thought that there would be a hesitancy on the part of you gentlemen to do it. It has seemed to me, from what I have read and studied of these things, that that might not be willingly accorded.

Senator MORGAN. My view of that situation is that we can not do it unless we subject this area over which this Government prevails to military law in time of peace as well as in time of war.

General, in the administration of this office you have had to be very painstaking, I suppose, and very active?

General DAVIS. I have done my best to discharge my duties. I do not claim any particular credit for that.

Senator MORGAN. No; I am not speaking of the credit; I am speaking of whether it has been a duty that was onerous.

General DAVIS. It was. The year I spent at Panama was perhaps a year of as great anxieties and as hard labor—mentally, of course—harder than any I can remember in my life.

Senator MORGAN. Either in Porto Rico or Cuba or the Philippines?

General DAVIS. Yes. Not because of the difficulties in the government per se, but on account of the inherent difficulties of the situation, without a definite knowledge as to the extent of the power of the governor, on account of the presence of a neighboring authority that pretended to certain powers of its own, even those that looked to the control of the judiciary in some instances, and since it was of the utmost importance, as I felt and as it was impressed upon me, to get along harmoniously with this neighboring authority; the sovereign Republic of Panama, it was always a source of considerable anxiety to me to know just how to direct my steps so that friction could be avoided, so that harmonious results could be obtained.

The absence of any idea of summary action I endeavored always to inculcate among my subordinates—among those I relied upon to assist me in carrying on the work—and so it left a situation with some anxieties. But I do not know, if I had it all to go over again, whether I could do any better.

Senator MORGAN. Have you any suggestion of any important law for the control of that Zone that you think ought to be enacted?

General DAVIS. I think this basis of government that has been announced by the President (on the 9th of May, 1904), together with certain Executive orders that have since been published, and certain legislation that has been enacted by the Commission since, furnish a basis of governing the Zone that can be carried on practically. It is not the simplest form of a government that can be conceived, but it is being applied now, as I understand, without friction and without special difficulty. I learned that by conversations with Governor Magoon, who has been here recently, and he seems to be getting on well and without friction or difficulty.

As an ideal proposition I think the vesting of a chief executive in the Zone with very considerable executive power, and simplifying the application of that power as much as possible, is desirable; but I would hesitate to attempt to point out in detail how that variation might be effected. It would be a difficult matter. It is one involving a great deal of study, for while the Zone is a little place, is a small affair in territory, is small in population, yet a single individual who resides in it has certain rights, or what he feels to be his rights, and those are just as important to him as if he lived in the city of New York or Paris or London, and therefore a proper regard for the rights of the individual is just as important to the governor of the Zone as it is if he were governor of Illinois.

Senator MORGAN. Was there any friction of any important character between the Government of Panama and the government of the Zone?

General DAVIS. Friction of an important character? That would depend upon the point of view individually. I do not think there was, and I do not know of anybody by name who did, but the newspapers made much of it and a great deal was published about friction existing between the governor and the Republic of Panama, and all kinds of stories were printed and falsehoods circulated without end, and public sentiment was created, perhaps.

I don't know whether I would say that there was a public sentiment, but there was a sentiment expressed very generally in newspapers throughout the country that there was great necessity on the part of the Administration to harmonize these questions at issue between

the governor of the Zone and the Republic of Panama, and whether that was the cause of action or not I don't know, but Mr. Taft visited the Isthmus in, I think it was December or February, 1905, and had very full and free discussion of these various questions that were then the subject of some irritation with the President of the Republic and his cabinet, with the governor of the Zone and his officers, and as an outcome of that discussion a new basis of treating certain questions was established.

Senator MORGAN. Established temporarily?

General DAVIS. Well, established for the time being. All of this is temporary, I suppose, until Congress shall act. But he established certain bases of action and put them into force. And the authorities of the republics were very happy over it, felt that they had accomplished a part, at least, of what they set out for, and the administration of the government under those modified instructions went on without friction or difficulty, and the rules were carried into effect just as before.

Senator MORGAN. These questions that had to be settled related to commercial and financial affairs?

General DAVIS. Largely so; yes, sir. The authorities of the Republic insisted that they were partners in a certain sense with the United States in the exercise of judicial functions in the Zone. The minister of foreign affairs addressed me letters on that subject asking me to arrange with him for the appointment of a commission looking to the adjustment of that question, which I declined to do; but I know that he insisted that certain functions of government still resided in the Republic of Panama with respect to the Zone. Since then, so far as I know, he has not revived that question.

Senator MORGAN. Did that question arise in consequence of some judicial action taken in the Zone?

General DAVIS. I think it arose in respect to some particular court's proceedings. Some man had a cause in hearing in the courts of the Republic before the Zone was established. When the Zone was established and this judicial proceeding had not yet been concluded the judge handling that case passed it over to the minister of foreign affairs of the Republic, and he passed it over to me as governor, and I referred it to the judge of the district court, or the proper court, so that it might be concluded in that court.

Now, I know that that was one case. Another was a case of similar nature that had been carried partly through its career and had not been transferred to the governor of the Zone. The authorities of the Republic thought, probably—of course I can not say what they thought, but only judge of their thoughts by their actions—thought, probably, that they had some rights still vested in themselves in regard to the handling of these cases, and some such case as that was not transferred, whereupon the plaintiff invoked the authorities in the Zone to open the case de novo, as the property involved was situated in the Zone. That resulted in this controversy and discussion, and resulted in the proposition made to me by the minister of foreign affairs to appoint a commission for the purpose of considering and adjusting this whole matter. As I said before, I declined to enter upon that.

Senator MORGAN. In a criminal procedure in the Zone, were any exceptions taken to the judges in the courts by the Panama Canal Company?

General DAVIS. No.

Senator MORGAN. There was a lottery case that came here.

General DAVIS. Yes.

Senator MORGAN. Did that originate in one of your courts?

General DAVIS. Yes; that originated by orders given to the chief of police to arrest men carrying on gambling operations in violation of the local law, the law applicable to the Zone. The arrests were made. They happened to be Chinamen, I think, and those men were brought before the municipal courts—the lowest court—and remanded to a higher court, and then bonds were given for appearance and an appeal taken, and finally, in some way or other—I don't know how and I never could quite understand how—they managed to get the case before the Supreme Court of the United States.

Senator MORGAN. On a motion for certiorari, I think?

General DAVIS. Yes.

Senator MORGAN. And the Supreme Court declined to take jurisdiction?

General DAVIS. Yes.

Senator MORGAN. And so the judgment of the Zone court stood?

General DAVIS. Yes.

Senator MORGAN. And has been enforced?

General DAVIS. Yes.

Senator MORGAN. Did the governor of Panama complain of that judgment?

General DAVIS. No, not to me; if so, it has been since I left there.

Senator MORGAN. And that was a lottery law that claimed to have been enacted by Colombia or Panama?

General DAVIS. By Colombia.

Senator MORGAN. Granting a gambling franchise?

General DAVIS. A monopoly of gambling, yes; for which a man paid a certain sum.

Senator MORGAN. Just what does that mean—"monopoly of gambling;" does that mean all kinds of gambling?

General DAVIS. I am not certain that it means all kinds, but he was privileged to conduct the kind of gambling that the people of Panama engaged in, which is the usual gambling, I think, principally roulette; I have forgotten now what else. Roulette I think is the principal gambling game that they engaged in. He had the right to conduct under this franchise all those games and was required to pay over to the Republic a stated sum per month or quarter.

Senator MORGAN. And that concession or monopoly extended down into—

General DAVIS. It expired some months ago and has not been renewed.

Senator MORGAN. And was in force at the time you were there?

General DAVIS. Yes.

Senator MORGAN. So you succeeded in stopping gambling?

General DAVIS. Yes; that was stopped absolutely. There is no gambling in the Zone carried on now unless it is done secretly and by connivance.

Senator MORGAN. There is none carried on under a license?

General DAVIS. No, sir; there is none carried on under a license, and the chief of police had from me and has from the present governor orders to prevent it, and he has been told in effect that this gambling

can not exist without his knowledge, and if it does go on the governor will know that he is incapable of enforcing the law and will get some one else.

Senator MORGAN. That seems to cover sufficiently the question of judicial friction, if any has arisen. Now, about the commercial friction that arose there; what was the character of that?

General DAVIS. That was largely based on a misapprehension—an idea that merchants of Panama conceived that their trade was going to be taken from them by a combination of circumstances that were to come about through the fact that the United States was going to implant in the Canal Zone the fiscal system which we have in the United States; that is, that the Dingley rates of duty were to apply to all importations into the Zone. They thought that we intended to bring into the Zone everything that we needed for our own use or that offered for sale in private establishments likely to be required or used by the inhabitants of the Zone—men, women, and children—in other words, that free trade between the United States and the Zone was to exist.

They said that if this is the case, then, as the limit of the Zone is an undefined one, as it is simply a question of crossing the street in some cases, as the country is covered with a jungle in large parts, goods brought into the Zone free of tax or duty can be spirited across the border and their own revenues depleted unless they had some control over the entry of those goods into the Zone in the first place. Now, that was their fear. The entry and clearing of vessels to the two ports, Christobal and Colon, which were two new ports created by executive order of Secretary Taft, was an evidence in their minds that this very danger was impending and was certain to exist, and that the effect of it was going to be very disastrous to them. These representations were made and circulated.

They felt that for the United States to enter and clear a vessel from La Boca, which was called the port of Ancon, a new name that was applied to that municipality, was an act which infringed the rights of the Republic. The Hay-Varilla treaty describes how certain harbors and ports are to be treated—that is, the ports of Colon and Panama. They considered that the harbor of Panama included La Boca.

It seemed to me that it could not possibly be so; that the United States could not possibly admit that La Boca, a part of the canal itself, the very prism of the canal which we have bought and paid for—that we could not possibly admit that that particular piece of the canal prism $2\frac{1}{2}$ miles from the city of Panama and 3 or 4 miles away from what was formerly and what has usually been called the harbor of Panama—it did not seem to me possible that the United States could tolerate the idea that La Boca—that is to say, the mouth of the canal on the Pacific side—could be conceded to be within the exclusive jurisdiction of the Republic of Panama, and upon that basis I negotiated with the authorities of the Republic and endeavored to arrive at a *modus vivendi* in respect to the limits of the Zone.

That was one of the first things I did after I arrived on the Isthmus. And fortunately—I say fortunately because Secretary Taft has so described it—an arrangement was arrived at, and then the governor of the Republic, Mr. Arias, was the minister of foreign affairs, and an agreement was arranged delimiting the Zone territory on a provisional basis until it could be taken up and decided by a higher authority.

Now, the doing of this brought about a state of affairs in the Republic which seemed to them to indicate the certainty that these trade conditions were to prevail; that if they prevailed the interests of the merchants of Panama would be greatly impaired.

Their representations to the authorities of the Republic brought about this condition which I have referred to earlier in my remarks; that is, a condition where it was said in the public press that friction existed between the governor and the authorities of the Republic. Now, those were adjusted by Secretary Taft; they were harmonized by concessions on each side, perhaps. I think certainly there were concessions on each side, and a basis was arrived at that has been in operation since, satisfactorily in operation since, as far as I know.

Senator MORGAN. That is what is embodied in what is called the *modus vivendi* and is already in our records.

General DAVIS. Yes; that is in your record.

Senator MORGAN. And we will not go into an examination of that; at least I will not.

General DAVIS. It has worked very well and it applies to the trade and applies to the postal system and applies to the entrance and clearance of vessels.

Senator MORGAN. And to the fiscal system; the money?

General DAVIS. Well, that was not embraced in the agreement I made; that was not in that.

Senator MORGAN. That was subsequent; yes.

General DAVIS. A subsequent agreement. But his later arrangement with the Republic covered that fiscal matter. I never had anything to do with that fiscal matter; that never came to me at all.

Senator MORGAN. At the time you were there as a member of the Commission and governor of the Zone did you recognize that there were any material difficulties in the money that was in circulation, using it for canal purposes?

General DAVIS. There were inconveniences, yes. When I arrived there the money in circulation in the country was the Colombian silver, the peso and the media peso and the smaller denominations, fractional currency. That money was a coinage that was applicable to the whole of Colombia, but it did not circulate except on the Isthmus of Panama. That is, it was money of Colombia proper, but on account of the issue of paper money in Colombia it did not circulate in Colombia. It disappeared entirely from circulation in Colombia, and the exchange for silver in the Colombian markets was 10,000 to 1, paper for silver.

But Panama always maintained a metallic basis for its currency; even before the secession or independence it always had a metallic basis for its currency. That is to say, there was nothing marked on these Panama Colombian dollars to indicate that they pertained particularly to Panama, but the fact was that they were in circulation nowhere else but on the Isthmus of Panama. And there it was the only money in circulation, except a small amount of English money, or American money, or French money, and some little Peruvian money.

Generally the money in circulation was this Colombian silver dollar, with no other mark on it than the Colombian mark, and which was a legal tender in the Republic of Colombia everywhere, but practically out of use in the Republic except in Panama. The French in carrying on their work had proceeded on just the same basis that we

would proceed if we were doing a piece of work in France; that is to say, in paying off labor we would buy francs and disburse francs and their other denominations to our laborers, supposing we were carrying on our work in that way; the Frenchmen did exactly the same thing.

They had every two weeks a certain bill to pay for the labor of those two weeks. Calculating it, they went to banks and bought that amount of Colombian silver and then disbursed it. The money came into their hands and passed out into the hands of their employees, and in a little while it would come back into the hands of the bankers and merchants.

Senator MORGAN. And they would pay for that Colombian money by exchange on Paris?

General DAVIS. That is the way the Frenchmen did. When I arrived there with instructions to carry on the work as the French had carried it on, I had no discretion and I proceeded in the same way. When our first day for paying came around our disbursing officer said, "I have some United States money here but no local money, and these men are in the habit of getting their money in Colombian silver." I said, "Post up an advertisement asking for bids for furnishing as much money as you want for your next pay day, and submit those bids to me."

He posted up that notice, advertised for bids, and told these people that he would give them checks on the assistant treasurer in New York for the amount of silver that he wanted to buy for use in disbursement to our employees, and that he would accept bids for the whole or any part of that, depending on which was the lowest. He submitted an abstract of those bids to me, checking off against each the aggregate, and we accepted the lowest bids. I approved the schedule and ordered him to make the purchase of silver, and he bought it and disbursed it. And the vouchers were submitted to the Treasury Department and they showed that these particular men were paid by money derived in such and such a way, and the rate of exchange would be stated, so that everybody who handled the papers would know everything that occurred in regard to the transaction.

That continued, and our disbursements became larger as time went on, and business became more and more important. It was a business that the bankers did not relish; that is, the way we administered it they did not relish. We asked for public bids for this money; we treated it as a merchandise and told the merchants of the Isthmus that we wished to purchase so many articles called pesos, and asked them what price they would sell for. The Frenchmen had not proceeded that way; they had gone to the bankers and had said, "What is your rate to-day on Paris?" Then they would get the quotation, and then they would get the amount of silver necessary to pay off their men and pay for it with a draft on Paris, and the public knew nothing about it.

The bankers, Ehrmann & Brandon, and the other banking house there were not pleased with this method that we Americans pursued of publicity, and there was a good deal of criticism about it—mere criticism, which did not amount to anything; it never bothered anybody, but still there was a feeling that the banker was treated with scant courtesy. In other words, I remember Mr. Brandon on one occasion said to me: "We will furnish you with all the money you want if you come to us for it, but we are not going to bid for it in competition with every Chinaman and every other fellow here who

wants to bid. We are bankers, and we will not put ourselves on a level with all these people." But it didn't make any difference: we got all the money we wanted.

Of course there was a constant desire on the part of the people who bid to get as high a price as possible for their silver, and the rate was continually fluctuating. I think we bought it at a rate as high as 115 or even 120—that is to say, it sold for 215 in silver, 220. I don't know but what in some instances it went as high as 225. It was continually changing up and down, and it is very unsatisfactory to have a money that was so fluctuating as that, and the conditions were as I say. Later on the International Banking Corporation of the United States, incorporated, I think, under the laws of Connecticut—

Senator MORGAN. New York, was it not?

The CHAIRMAN. Under the laws of Connecticut, I think.

General DAVIS (continuing). I thought it was Connecticut—established a branch bank on the Isthmus and the manager of that bank had the idea that he was going to control the whole money situation; that is, he had an idea that the Government of the United States was going to deposit with him a large amount of currency and that in consideration of that he could afford to furnish to the disbursing officers the necessary amount of local silver. This was before the Panama silver had come into use. He thought the Government of the United States would keep a large enough deposit with him to justify him in doing that.

It was found that the national banking act did not apply to the banks maintained outside the territory of the United States, and so they could not establish a national bank on the Isthmus. That proposition failed, and then the new coinage came into use, brought about in the manner in which you know, and concerning which I had nothing whatever to do. It came into use. The agent of the International Banking Corporation at first said: "I am going to try to handle this whole thing for you without charge—I am going to try to do it. I don't know whether I will succeed or not, but I am going to make an effort."

The first two or three months after the new Panama currency came into circulation the International Banking Corporation received from our disbursing officer his checks on the assistant treasurer in New York at par, and paid over the money at par; that is to say, for \$1 of the United States money he gave the disbursing officer \$2 of Panama silver. He said: "I don't know how long I can keep this up, but I am going to attempt it." I know it continued for about two months, and then the quadrilateral agreement was made which you have taken so much testimony about.

That agreement was entered into by the four banking houses. They all agreed among themselves, severally, but not conjointly, I think, to supply the disbursing officer with all the money he wanted at par. Since then I understand that plan has been continued and the disbursing officers have received Panama silver for United States checks on the United States assistant treasurer in New York at their par value in gold; that is, \$2 Panama silver for \$1 American paper or gold. The arrangement that was made has worked well enough, so far as I know.

The only unfavorable feature of it, I think, is that if an employee of the United States wishes, out of his accumulated savings on the Isthmus, to send a check home, he can not go to the disbursing officer

and get it without expense, but he has to go to a banker and pay for it. I think it is three-quarters of 1 per cent, or something like that, that he is charged. I don't think that is fair, and it ought not to be, but is not a very important matter, and is one concerning which I had no instrumentality in any way.

The statement has been made in respect to this money that it would not be possible to use American money on the Isthmus without great inconvenience; that it would result in the enhancement of the price of everything. It had been urged that if you would pay the laborers of the United States in American money, and since a coin of the size of their peso would cost that employee twice as much as the peso—that is to say, it would pay for twice as much labor as the peso would pay for—that he would see no reason why that particular coin of such a size should be worth more than another coin of the same size. That is the argument, I think, that has been made here, and I suppose there is some basis for it.

But the experience I have had on the Isthmus, coupled with the experience had in Porto Rico, when they changed the money of Porto Rico, has made me come to this conclusion: That if I had it all to do over again and it was an original proposition, instead of one that has been handled by others and settled in a certain way, I would go at the thing exactly the other way; I would pay every man for every day he earned or every commodity I purchased on the Isthmus of Panama in United States money; I would pay out the greenbacks or gold or silver, just as the case might be, at its face value, and I would expect that what would certainly happen would be that within a month or two or three everybody would adjust themselves to the situation. It worked exactly that way in Porto Rico.

Senator HOPKINS. May I interrupt you?

General DAVIS. Certainly.

Senator HOPKINS. Is there not this difference between Porto Rico and Panama: That in Porto Rico you have a considerable community and that on the Isthmus down there you are getting people from Martinique and from that place and this place, and they are constantly changing?

General DAVIS. Yes sir; but there is a great permanency; there is a great stability as respects nationality of the people who are now flocking to Panama. That is to say, they are English or French negroes. Those English and those French negroes in Jamaica and Martinique and Guadeloupe have no knowledge of any other money than gold; they never saw a coin that does not represent gold value; there is not one of them in Jamaica that knows about any money except shillings.

Senator HOPKINS. It seemed to me that it would be very proper to use American money in Porto Rico, because that is a permanent civilization there, and it has a more permanent population; that is, to be a part of the possessions of this country for all time, and hence the quicker that they learn the methods that we use in a financial and commercial way the better for them. The quicker they become familiar with American money the better it is; but I do not think that idea would prevail to that extent on the Isthmus.

General DAVIS. There are two facts in regard to that matter that I think I may refer to, with your permission, that may have a bearing upon it. The exchange made for the money of Spain for the money of the United States in Porto Rico was on a basis of 70 for 100; that

is to say, we paid 70 cents for one of their dollars, and we took up all of the Spanish money in circulation in Porto Rico—which, by the way, every coin of it, had the words "Porto Rico" stamped on it—and brought it to Philadelphia and melted it up. But we paid for it an American 70 cents for a Spanish 100 cents.

The other fact I wanted to refer to is this: I said if this was a new proposition I would proceed so and so; but it is not a new proposition, and what has happened makes my remarks perhaps inapplicable, and that is this: The Secretary of War and a commission appointed by the Republic of Panama to discuss this subject of a currency for Panama have arranged a certain *modus vivendi* or basis for understanding, or protocol, or whatever it may be called, and under that the Republic of Panama has gone to work and coined \$3,000,000, and that puts the thing on a different basis entirely.

We have encouraged them to do that. We not only got them to coin \$3,000,000, but then we found that there was a deficiency of money for circulating purposes, and then we asked them to coin another million, which they did. So it is not an original proposition, and we can not revert to the status quo ante, and I only remarked if we were to start all over again that would be my idea of the way to treat it.

Senator MORGAN. I would like to ask you to give a description, first, of the taking over of the property of the Panama Canal Company and Railroad Company by the United States. You were there, I believe, and conducted that operation?

General DAVIS. Not exactly, Senator; but I will explain. The passage by Congress of an act authorizing the President to organize a government for the Canal Zone, which I think was approved about the 1st of April, 1904—I am not sure of the date, but that is about the date, I think—upon the approval of that act instructions were sent to Paris by the proper officer of the Government (I don't know who) to take over the property of the new French Canal Company and to arrange for the payment of the money. All I know about that is what I have read.

At the same time that order was given, concurrently with it or concurrent with the actual taking over of the property in Paris, I think instructions were sent to an officer of the Army, on the Isthmus of Panama at that time. I refer to Lieutenant Brooke, of the Corps of Engineers. Those orders directed him to receive from the director-general of the Panama Canal works on the Isthmus all property of the Panama Canal Company. I was at that moment in this city. This telegram was sent to Lieutenant Brooke and was received by him on the 3d of April and, if I remember correctly, was acted upon on the 4th of April, the director-general of the New Panama Canal Company on the Isthmus having received the same day instructions from the Paris office to do exactly the same thing.

Upon receipt of those instructions by cable Lieutenant Brooke waited on Mr. Renaudin and took over from him the property of the New Panama Canal, situated on the Isthmus of Panama, including all its offices, drawings, works of all sorts and kinds. I may be wrong about the date; upon reflection I do not think it was the 4th of April, but the 4th of May; I think I was a month off in stating my dates. But that is not very important. I arrived on the Isthmus on the 17th of May. This transfer had taken place, I think, on the 4th of May. I found Lieutenant Brooke in charge of the works, so that my functions

in connection with the transfer of the control of the property were almost nil, the transfer having been effected about ten days before I arrived there, and all the correspondence between Lieutenant Brooke and Mr. Renaudin is all printed in one of these documents which you have before you.

The transfer of the Panama Railroad was never made to me at all. The orders I received from the president of the Isthmian Canal Commission, I think, dated the 8th of May, directed me to proceed to the Isthmus and take over from Lieutenant Brooke all this canal property, but specifically excepted the Panama Railroad, so that I had no authority over the Panama Railroad at all.

Senator MORGAN. Was the railroad property taken over at the same time that the canal property was taken over?

General DAVIS. The railroad property was never taken over at all in a physical sense. The United States purchased 68,900 shares of the Panama Railroad stock from the New French Canal Company, and the control of that stock permitted the Government of the United States to control the board of directors and put new men in office and control the management through the board of directors. So that in a physical sense there was never any transfer of the property of the Panama Railroad Company to the United States. I had nothing to do with it, and I am only speaking of that by general information.

Senator MORGAN. That is to say, there was no actual delivery?

General DAVIS. No; none at all.

Senator MORGAN. But the property went into the possession of the United States?

General DAVIS. Oh, of course it went into the control of the United States through its own agents, the directors.

Senator MORGAN. From the date of the transfer of the Panama Canal?

General DAVIS. When transfer of the Panama Canal was effected, an annual election had taken place only one month before, I think. The annual meeting of stockholders, I think, occurs in the first week in April, and the transfer of the canal property was made in May, and a new board of directors had been elected and gone into office for the Panama Railroad on the 1st of April. They are elected for one year; they stay in office during the remainder of the period for which they are elected, unless they see fit to tender their resignations earlier, or for some reason a vacancy occurs.

So that some of the board of directors who had been chosen while the canal company was the owner of the stock remained in office until the next annual election took place. I think there were a few changes made, meanwhile. I think several members of the Isthmian Canal Commission, the old Walker commission, were elected to places on that board of directors on account of the resignations of other persons; but there was no general change of the directorate of the railroad until the ensuing annual meeting of the stockholders took place.

Senator MORGAN. In April, 1905?

General DAVIS. In April, 1905.

Senator MORGAN. Do you know of any order of the board representing the Panama Railroad Company transferring its property to the United States?

General DAVIS. No, sir; I do not know anything about it; I never sat with them in a board meeting in my life.

Senator MORGAN. You were not a member of the board?

General DAVIS. I believe I was elected a member of the board of directors while I was on the Isthmus, but I never met with my colleagues at all. I remember I was informed that one share of stock was put in my name, and I was sent a check for \$5 in payment of a dividend on the stock, which check I indorsed over to the Secretary of War, and that closed the incident so far as I had anything to do with the stock of the Panama Railroad Company. As I have said, I never met with the board at all.

Senator MORGAN. But you met with the Isthmian Canal Board.

General DAVIS. With the Isthmian Canal Commission, yes; I think they had eighty-five meetings, and I think I was present at seventeen of them.

Senator MORGAN. Were you present at the first meetings?

General DAVIS. Yes; a few of the first, and then three or four or five or six in August.

Senator MORGAN. But nearly all those meetings were held here in Washington?

General DAVIS. Yes.

Senator MORGAN. And you remained in charge at Panama?

General DAVIS. I was at Panama for a year, except in the middle of the summer for two weeks, when I was in the United States on a special personal errand.

Senator MORGAN. I notice that on the 20th of May, 1904—that is, while you were governor?

General DAVIS. Yes; I was on the Isthmus, then.

Senator MORGAN. And you were a Commissioner, then?

General DAVIS. Yes, sir.

Senator MORGAN (continuing). The following letter was laid before the Commission:

“WASHINGTON, D. C., May 20, 1904.

“Rear-Admiral JOHN G. WALKER,

“*Chairman of the Isthmian Canal Commission,*

“*Washington, D. C.*

“SIR: The New Panama Canal Company, through its president, and Mr. Cromwell, its American counsel, has notified the President that it is desirous of taking up and disposing of the question of compensation claimed by the New Panama Canal Company for construction upon the new Panama Canal during the negotiations that have just terminated in a transfer of that property to the United States. I am directed by the President to notify you that he will expect the Isthmian Canal Commission to take up the question with the New Panama Canal Company with the view of determining what the facts are in relation to this claim, to the end that if possible when the matter ultimately comes before the President for decision it will involve only the question as to whether or not the claim is well founded and he has authority to pay it.

“Yours, respectfully,

“P. C. KNOX, *Attorney-General.*”

You became acquainted with that demand at that time?

General DAVIS. I was not present then, as you see. I was on the Isthmus; but copies were sent to me, and as I read them I of course became familiar with what had transpired in the Commission as recorded.

Senator MORGAN. Was this subject ever brought to the attention of the Commission while you were present?

General DAVIS. No, sir; never at any board meeting at which I was present. I have heard the members of the Commission talk about it in an informal way, but I have never heard it discussed formally or officially at any meeting at which I was present.

Senator MORGAN. Was not the date of the taking over of this property in Paris the 16th of April, 1904?

General DAVIS. I think that was the date when the title papers were passed; but the instructions sent to Lieutenant Brooke on the Isthmus were not until later than that. I can not remember now exactly the date, but they were later than that. I think that is the date of the actual transfer of the papers, but I think some time was consumed in passing them through their various stages.

Senator MORGAN. The paper I have just read to you is dated the 20th day of May.

General DAVIS. Yes.

Senator MORGAN. I find on page 60 of the proceedings of the Isthmian Canal Commission, from March to September, 1904—during all of which time you were a Commissioner, were you not?

General DAVIS. Yes, sir.

Senator MORGAN. I find the following:

“DEPARTMENT OF JUSTICE,
“Washington, D. C., March 10, 1904.

“MR. WILLIAM NELSON CROMWELL,

“General Counsel, New Panama Canal Company.

“SIR: I have received your letter of the 9th instant concerning work done on the Panama Canal since execution of the work included in the Isthmian Canal Commission's estimate of \$40,000,000 as the value of the Canal Company's property. The President directs me to say, that without committing himself to any proposition of fact or law stated in your letter, he is willing to determine what amount, if any, the company should receive on account of such work in addition to the price of \$40,000,000 agreed upon.

“Respectfully,

“P. C. KNOX, *Attorney-General*.

“Signed at Paris, France, April 16, 1904, by W. A. Day, assistant to the Attorney-General; by Charles W. Russell, special assistant Attorney-General.”

That letter seems to have been withheld from delivery to Mr. Cromwell from its date, the 10th of March, 1904, until April 16, 1904, and antedates the letter of Mr. Knox that I have just previously read by one month and four days.

On that date the minutes of the Commission show that Mr. Cromwell made the following statement:

“Gentlemen, upon the statement of the case, which I have read for your information, I recently applied to the President to proceed with the arbitration, and he divided the work of his duties into branches. He has, as I understand it, referred all questions of fact concerned in the claim to the Commission for its advice, and all questions of law to the Attorney-General; so that upon the Commission's report the whole

matter may be considered and determined by the President, with the advice of the Attorney-General.

"Following the general basis of the claim, which is embraced in the communications which I have read to you, I have delivered to the Attorney-General, for the President, the detailed statement of claim, of which I now hand you a copy for your own use. You will, of course, want to examine this statement of claim more in detail; but I will now read so much of it as I think will assist you at this session."

And then he goes on to present the claim. It covers several pages, and an affidavit is made to the claim by Mr. Louis Chorin, who was the chief engineer of the new Panama Canal Company.

General DAVIS. He was.

Senator MORGAN. Were you ever present at any time when that claim was being considered by the Commission?

General DAVIS. I never was.

Senator MORGAN. Did you ever have any conversation with Mr. Cromwell about it?

General DAVIS. Never; not a word.

Senator MORGAN. Do you know what the opinion of the Commission was as to the validity of the claim? It seems never to have been taken to final settlement.

General DAVIS. I have been told by members of the Commission that they made a report, that they sent that report to the Secretary of War, in which they expressed the opinion that there was no basis whatever for the claim, but I never saw the document and only know of that from verbal statements made to me.

Senator MORGAN. Do you know whether that claim is being pressed before the Department now?

General DAVIS. No; I do not know officially. I have no official knowledge on the subject, although I have heard it as a matter of common conversation that it is being pressed.

Senator MORGAN. One of the present Commissioners stated the other day that he was examined about it in the Department of Justice.

General DAVIS. I had heard that also.

Senator MORGAN. As I understand this claim, it dates from the date of the first proposition of the Panama Canal Company made to Admiral Walker for the sale of the property of the Panama Canal Company, including its shares of stock and all the property on the Isthmus.

General DAVIS. I have had the same understanding, although I do not know. I have not read with any great care the presentation there made by Mr. Cromwell himself. That would disclose the scope of it, I think.

Senator MORGAN. I want to ask you in connection with that claim, what was the condition of the work on the Isthmus in regard to opening up the canal and completing it at the time you first saw it?

General DAVIS. You mean the extent of progress?

Senator MORGAN. Yes.

General DAVIS. The condition as regards points of activity?

Senator MORGAN. Activity, and also the character and condition of the machinery, and anything else about it.

General DAVIS. To answer the last part of the question first, I should say that you might as well eliminate the machinery as having any particular value. There was some value in the stuff that was under stor-

age; there was some value to the buildings that existed on the Isthmus; there was some little value in some of the machines; we got some useful work out of some of the machines; but taking it altogether, I should state its value as a very small one.

The points of activity—there was only one, and that was the Culebra notch. There were five or six or seven hundred men at work there when I arrived there. When I first visited the Isthmus they were using one of the old French excavators; perhaps two of them were used during the first few months. They were dropped out pretty soon. The old French cars were being used, the French locomotives, Belgian locomotives, and the plant in use consisted entirely of the old French plant. That one point of activity was the only one. They had gone on with it until they had brought the bottom of the Culebra cut down to 165, as I remember, or maybe to 155—one or the other—they were taking out about 30,000 yards a month, as I recollect; maybe it was that many meters a month; 30,000 or 35,000 yards a month.

The records show that they had not very long before had an output as high as 60,000 or 70,000 yards a month with a larger force at work. Two years before that they had had 1,500 to 2,000 men at work, and the work included a point of activity near Empire at that time, but that had stopped when we arrived, and there was only one place where they were doing any work, and it was common talk all over the Isthmus that work was being done, not with the idea that it counted particularly toward the final result of a canal, but that it kept alive the concession which they had received from the Government of Colombia, and if work should absolutely stop their concessions might be forfeitable.

The machinery was scattered everywhere along the line, along the side tracks, in the jungle; trees had grown up amongst the cars. I think there were 3,500 dump cars. I believe there were 60 engines of all kinds, and 6,000 or 7,000 of these little push cars made of metal, and a great many other tools and machines.

It was stated that this whole plant had a book value of \$29,000,000, but I inquired into that somewhat, and I found that it was the French practice that when a machine arrived on the Isthmus from abroad, where it was bought, they always wrote up 30 per cent additional of value over the purchase price as representing its value on the Isthmus as soon as it got there, so that this \$30,000,000, in round numbers, includes an added 30 per cent that was simply a book-account value. I suppose you would find the real cost of that machinery by deducting that 30 per cent from the \$29,000,000.

Senator MORGAN. What condition was the railroad track in?

General DAVIS. Very good; very good, indeed.

Senator MORGAN. How about the wharves?

General DAVIS. The wharves were in a very satisfactory condition; they were adequate for the limited business they were doing. They were entirely inadequate for the enlarged business that was to come. The La Boca wharf built by the French company was a metal affair on concrete foundations, and very well built, but a very inadequately designed structure. It was very long and very narrow, and it did not have space in which to work cargo economically; but it cost \$2,000,000 to the Panama Railroad Company; that is what they paid for it.

Senator MORGAN. That wharf extended perpendicularly to the coast out into the bay?

General DAVIS. It extended parallel to the axis of the canal, 200 feet away from the center axis of the canal.

Senator MORGAN. Did it reach out into the sea?

General DAVIS. No; not into the sea. There were mud flats all around it at low water, except on the side of the canal, which had been excavated. There was room enough for three of the San Francisco ships to lie there, the ordinary type of vessel running between Panama and San Francisco; three of them could tie up there at the same time.

Senator MORGAN. The channel, then, was dredged out?

General DAVIS. Certainly, they came up to this wharf, and do now, and have for the last three or four years.

Senator MORGAN. That channel is really a part of the canal?

General DAVIS. A part of the canal; yes, sir, certainly.

Senator DRYDEN. Is that the only wharf at Panama?

General DAVIS. The only one used. The old Panama wharf over on the other side of the city, where all the business of the transit was done until four years ago, lies to the east of the city. This wharf I speak of lies to the west of the city. This map will show you the situation. Here is Panama Harbor, so called, and that is the old Panama wharf, and the Panama Railroad comes down here [indicating on map]. The La Boca wharf is served by this branch [indicating on map], and that is what I insisted on taking into the Zone, and not leaving in the city of Panama.

Senator MORGAN. That La Boca wharf is in the Zone?

General DAVIS. Certainly, it is now; but if it had not been put there—well, if the earlier negotiations had not resulted as they did, I doubt very much if you would not have had a good deal of difficulty to-day in securing an agreement like that.

Senator DRYDEN. Who claimed the wharf, the city of Panama?

General DAVIS. Not the ownership, but the jurisdiction. The ownership was in the United States; nobody questions the ownership; the ownership was in the Panama Railroad, and the United States owned the stock.

I would say in regard to this zone of delimitation, that when Secretary Taft made his *modus vivendi* with the Government of Panama, in January, I think it was, 1905, one of the clauses of that agreement specified certain acts to be done by officers of the United States in pursuance of his orders that should not be done unless the Government of Panama ratified—that is, the representative of the Government of Panama ratified—and confirmed the provisional delimitation agreement that General Davis had entered into with the Government of Panama the year previous, and that the line of delimitation between the territory of the Zone and the territory of the Republic of Panama should be a line extending from Point Mala, on the shore of the Bay, over to the islands named Las Tres Hermanos, out to the 3-mile limit in the harbor, and that all water lying to the west of that line should be in the Zone, and all lying to the east of that line should pertain to the harbor of the city of Panama; and that requirement of Secretary Taft's order has been observed by the authorities of the Republic of Panama.

But that delimitation agreement has not, however, yet been made the subject of consideration by the National Assembly of Panama, so that it would be possible as a diplomatic act for the Republic of Panama to disown the agreement which the governor of the Zone

entered into with the Secretary of State in 1904. It would be a very unfortunate event if such a thing as that were to occur, I think, and I know of no intention to do it. I know of no purpose to endeavor to upset it; I have never heard of any.

Senator MORGAN. While this work was going on at the notch of Culebra, what was becoming of the prism of the canal that had before that time been dug out by the French, both on the Panama side and the other side—was it filling up?

General DAVIS. Oh, no; it was there as before. The part of the canal that had been dredged out toward Colon had filled up in a few places, had silted up at a few places. One place was at the mouth of the Mindi, where the silt coming in from the Mindi itself has blocked the canal prism, but generally you could go along in a boat where it had been dredged.

Senator MORGAN. Dredged down originally how deep?

General DAVIS. About 20 feet or 22 feet, I think. I sounded it myself in one or two places; I remember I found 20 feet in one place.

Senator MORGAN. It has been several years since the French made any attempt to keep that channel open.

General DAVIS. They never did a stroke of work on that channel after the work stopped in 1889.

Senator MORGAN. I refer to the dredged channel; they never touched that after that?

General DAVIS. No, sir; not on either side in the marine sections.

Senator MORGAN. Was the dredging out toward La Boca all filled up?

General DAVIS. Oh, no; it is there yet. You can sail up the old excavated channel in the mangrove swamps there in the Rio Grande lowlands in a small boat quite a distance. I have been up as far as Miraflores, not all the way in the excavated channel, but a part of the way in the old channel of the river.

Senator MORGAN. That has filled up considerably since it was first dredged?

General DAVIS. Somewhat, but not very considerably; I think not.

Senator MORGAN. What flow of water filled it up?

General DAVIS. Silt that would be brought in by the tide and silt that would come down from the headwaters of the Rio Grande and its tributaries; that would be the material that would choke it up.

Senator MORGAN. So silt did come in with the tide?

General DAVIS. Mostly with the tide, I think. I think most of that trouble on that side was on account of the littoral drift. I do not think that the silt from the highlands has much influence in blocking up the lower Rio Grande.

Senator MORGAN. When the tide comes out to its lowest stage there is quite an area of country left there?

General DAVIS. Yes; left exposed.

Senator MORGAN. And then when the tide comes in—

General DAVIS. It covers it again.

Senator MORGAN. And washes it up against the coast?

General DAVIS. Just simply the water lies over it, floods back over it, just as it does on the tidal marshes in Georgia and South Carolina, the same way; the tide floods over it and then recedes twice a day; it comes and goes. Of course it is salt water, so there is no grass growing in it; but these mangrove bushes are growing there. They are

what we call mangrove in the United States; they call it mangla down there.

Senator MORGAN. When you took command of the Zone you found 600 or 700 negroes there that had been formerly working under the French, did you not?

General DAVIS. Yes.

Senator MORGAN. And Major Black was in charge of them?

General DAVIS. Yes; Major Black had charge of the work.

Senator MORGAN. You continued those men at the work?

General DAVIS. I continued them straight on, and when Mr. Wallace came in July he continued them and added more to the force.

Senator MORGAN. Did he add considerably to the force?

General DAVIS. Very much; very much. I think he worked up the force from 700 to 7,000 or 8,000. I do not mean to say at Culebra, no; he enlarged that force from 700 to I think 1,500 or 1,800—

Senator MORGAN. The whole force that he brought in—

General DAVIS. The whole force that Mr. Wallace had there at the time I left—I don't know of course what it was after that—was about 9,000, I think. That included sanitary and canal and everything else.

Senator HOPKINS. Right there I would like to ask a question, if you will permit me. In your judgment, was all that work well directed?

General DAVIS. Well, the sanitary work was absolutely indispensable, and there wasn't enough done, either. If there was any error made during that period it was in not spending more effort on the sanitary work. The work that was done in repairing houses and in constructing houses, in making sidings, and arranging for future work was all very valuable and of the most useful character.

Senator HOPKINS. Then you do not think that there was any squandering of money there?

General DAVIS. I don't think there was a dollar squandered; no. The work Mr. Wallace did at Culebra, I think, was work of the utmost value, because it revealed to him and to others, in their judgment, certain ideas as to what economies were possible; it was valuable to the critics of Mr. Wallace in showing where Mr. Wallace was mistaken. So it was valuable either way you put it. He alleged certain things respecting economy in which others did not agree with him, but the very fact that he had done this work at certain prices was an addition to knowledge which was valuable. I think there was no money wasted.

Senator MORGAN. How long was it after you were on the Isthmus as governor that this acquisition of labor began?

General DAVIS. It began almost immediately, very soon after—it began even with our going there, because all the West India world knew what had happened at Panama, and they had been waiting for the happening for years and years. There had been a former period of luxury and wealth "time of the empire," as they called it, when money flowed like water, and they wanted to see it again, and they had been waiting for it from 1899 way down to 1904, and then they heard the United States had taken hold and then the tide began to set toward Panama again.

Senator MORGAN. And the conditions in Panama were not requisite to their comfort or their entertainment or their health?

General DAVIS. Oh, no; there was not adequate accommodations for a very large influx, and it bothered us at times to take care of the men that we brought down there ourselves. It troubled us at sometimes

to take care of them in a proper way—that is, so you could offer a man a house that was fit to live in. It was a very perplexing question to do that sometimes, but generally we made out to do it.

Senator MORGAN. The question of supplies was a difficult one, also?

General DAVIS. Yes, sir; the question of supplies was difficult. We could purchase on the Isthmus whatever was available there and whatever we required, whatever was indispensable, if it was procurable there, we bought it. We bought many articles that were required by the sanitary department, and we purchased some things that were needed by the construction department. We bought quite a quantity of lumber that was brought down there by merchants on speculation, loaded at Gulf ports. We bought several small cargoes of lumber to use in constructing houses, lumber which had been sent there not for Government use at all, but had been sent there to be used in constructing private buildings, but as the lumber was for sale we purchased it. We purchased some little cement, some bricks, some lime, some hardware, some drugs, and various things of that kind. Other things that were not obtainable on the Isthmus we made requisition and sent for to the Commission in Washington.

Senator MORGAN. You had a large, rapidly increasing influx of people there that you were compelled to organize and provide for with shelter and food?

General DAVIS. Yes, sir.

Senator MORGAN. And to arrange them in such gangs as that you could use them for the purposes of preparation.

General DAVIS. Yes, sir.

Senator MORGAN. When you got there, and for quite a long time or a considerable time, I suppose, after you got there, the work on the digging of the canal was not in a state of preparation to be advanced successfully or economically?

General DAVIS. No; it was not, for we did not have the proper appliances for rapidly pushing the work. Our tools and apparatus were antiquated.

Senator MORGAN. You did all that could be done with the forces you had and with the machinery you were supplied with?

General DAVIS. Yes.

Senator DRYDEN. Did these laborers who came in to the Isthmus come voluntarily?

General DAVIS. Yes, sir; of their own accord.

Senator DRYDEN. They were not brought there at the expense of the Government?

General DAVIS. Some of them have been brought there at the expense of the Government since; yes.

Senator DRYDEN. Not the earlier ones?

General DAVIS. No; we didn't establish any agencies for the hiring of labor in the West India Islands until several months after we arrived there.

Senator MORGAN. It appears to be difficult to get labor to go there now. Do you know the reason for the difficulty?

General DAVIS. You mean mechanical labor?

Senator MORGAN. I mean labor of the kind that is used there in digging the canal.

General DAVIS. I think not, sir; I think there is an abundance there, I think it is flocking there; it is coming from Martinique and

Jamaica; they are flocking in there all the time, and I think there is a surplus there now.

Senator DRYDEN. They do not want to work more than three or four days in the week?

General DAVIS. They will only work when they are hungry. If they have money enough to feed themselves they will remain idle until the money is gone and then they will turn to work again. There is not such a thing in that country as laying up anything; they have no idea of anything like a savings bank.

Senator MORGAN. Taking the general condition of the country between the Bay of Limon and the Bay of Panama, state whether or not it had grown up with this rapid tropical growth, and whether the buildings and the roads, or whatever they had there, were in a forlorn sort of a condition.

General DAVIS. Yes; the place was grown up very largely to a jungle. When I say a jungle I mean low bushes, 2 or 3 or 4 or 5 feet, running up to 10 or 12 to 25 feet high. Senator Kittredge and Senator Millard have seen the character of the vegetation. Vines and creeping plants, tangling around and about and in and on everything, conceal and cover up the surface of the earth very quickly. Almost all the trees and some larger shrubs are covered with creeping plants—not insects, but plants—climbing plants, twining around and winding about, shrouds of vegetation, hanging down from growing trees that have not anything to do with the tree except as a parasite. That is the character of all tropical vegetation, the same as in other tropical countries I have been in.

Senator MORGAN. You had to clear that out before you could get a foothold?

General DAVIS. Yes; but the Panama Railroad was open all the way, and there were villages all along, and from each village it was easy to get here and there and on and about. There were bridle paths and trails from village to village, more or less; not roads, but paths sufficing for the uses of the natives; not very luxurious. They were not automobile roads.

The CHAIRMAN. Those bridle paths you speak of were along the right of way of the Panama Railroad.

General DAVIS. Yes. From Empire there was quite a lot of travel directly to the west, away from the railroad, over to a town called Cocoli, which is in the Republic back from the railroad.

Senator MORGAN. Were the men under your appointment and control there, as a rule, industrious and dutiful?

General DAVIS. Well, industry in the true sense—that is, I mean thrift in the true sense—does not exist on the Isthmus. There is nothing that I have seen that answers that description.

Senator MORGAN. You mean among the laboring classes?

General DAVIS. Yes; what we call thrift. There are four or five or six hundred Chinamen on the Isthmus, and they are thrifty, they save every cent they make, they never spend a penny that they can avoid, and it all goes back to China in the end.

Senator MORGAN. Do they live in the Zone?

General DAVIS. Some of them do. The Chinamen are the only gardeners that we have, they make all the gardens we have, and that is the only chance we have to get any fresh vegetables. The natives do not grow anything.

Senator MORGAN. What is the nature of the hygienic work that has been done there?

General DAVIS. Cleaning jungle, making ditches, miles and mile and hundreds of miles of shallow ditches, so as to drain pools and stagnant places; cutting away the vegetation so as to exclude the insects which, according to modern sanitary science, are the cause of a good many of our tropical diseases.

Senator MORGAN. Your task was a very heavy one?

General DAVIS. Well, it was a large one, and no man can work more than a certain number of hours a day, so that he found enough to do during his day and then he was ready to rest and sleep.

Senator MORGAN. Did you find any material on the Isthmus when you took charge there of proper character to repair the houses that were rotted down?

General DAVIS. No.

Senator MORGAN. You had to import it?

General DAVIS. All lumber has to come from outside. There is no lumber produced on the Isthmus available for temporary houses. There is a little mahogany shipped out of the remote points on the Isthmus, but that is far too valuable a wood to use in the structure of houses.

Senator MORGAN. The process of getting lumber there to make repairs must have been a slow one?

General DAVIS. Pretty slow. We had to send it from the United States, from Gulf ports, and from the Puget Sound country.

Senator MORGAN. It took you quite a while, I suppose, to assemble enough material there to make much of an impression upon those houses?

General DAVIS. Yes; quite a while.

Senator MORGAN. And in addition to repairing houses I understand you burned up a good deal—

General DAVIS. We burned up the refuse that came out of the houses that were partly in ruins; we burned up some refuse.

Senator MORGAN. You burned up some houses?

General DAVIS. I did not. Maybe that has been done since; I don't know about that.

Senator MORGAN. In making all this preparation, this cleaning up, you had to take things from the stump, as we say?

General DAVIS. Yes.

Senator MORGAN. There was nothing provided?

General DAVIS. No.

Senator MORGAN. The French left nothing there that was of any material value?

General DAVIS. They left a good deal of hardware; they left a good many kinds of ironmongery—I mean in stock, bar iron, bar steel, copper, pig lead, Babbit metal, spelter, zinc, galvanized iron, many kinds of tools, hydraulic lifting devices, steam engines, small donkey engines, pumps—and a great deal of that material came over to us and saved us quite a good deal in the way of preparation when we had that to fall back on.

Senator MORGAN. Have you instituted machine shops there?

General DAVIS. Yes; we took those French shops. There were in all five French shops on the Isthmus. We put every one of them into use. We overhauled the machines; we repaired some, disused others,

enlarged several. There were two brass foundries, two cupolas for making small castings; there were planers and drill presses and lathes and milling machines, and all those usual machines that you find in machine shops. They were there ready to put on a belt and start them right off, some of them, and some others had to be overhauled and leveled and lined up.

Senator MORGAN. You got your fuel there—coal, I suppose—from the Panama Railroad?

General DAVIS. We got it from the Panama Railroad. They were importing all the time, and we got ours from them.

Senator MORGAN. And you made your purchases from the Panama Railroad of fuel?

General DAVIS. Yes; they sold it to us.

Senator MORGAN. And they furnished you chiefly, if not entirely, the transportation with which you had to provide yourselves for all these necessities?

General DAVIS. They furnished and have since furnished all the through transportation over the Panama Railroad, but the transportation for hauling earth out of these working places has never been done by the Panama Railroad. Recently it has been necessary to use the tracks of the Panama Railroad to some extent. That is done under the general trackage arrangement; but the dump trains, the trains hauling earth and rock, are trains made up exclusively of rolling stock that has no connection with the Panama Railroad, and that operates on tracks that are not in any way under the control of the Panama Railroad Company.

Senator MORGAN. During all the time of your administration there I suppose, from evidence that has been presented here, the Panama Railroad was considered as a separate and independent corporation?

General DAVIS. Yes, sir.

Senator MORGAN. You had to make deals with them, traffic deals and everything of the sort?

General DAVIS. Yes, sir.

Senator MORGAN. And these tracks upon which you haul earth out of the diggings were made by the Isthmian Canal Company?

General DAVIS. By the Commission.

Senator MORGAN. And you made your arrangements for mileage, I suppose?

General DAVIS. Yes, sir.

Senator MORGAN. Upon the Panama Railroad?

General DAVIS. Yes, sir; most of that work was handled, I think, by the chief engineer and his chief of department of material and supplies; I think he was the one that handled the negotiation. I had no personal dealings with respect to those negotiations with the railroad, but it was managed by men by whom its performance was appropriate.

Senator MORGAN. The meetings of the board of directors of the Panama Railroad Company were all held in New York, were they not?

General DAVIS. I think all of them. I think they always have been. Although I am not exactly sure about that, that is my understanding. I tried to induce the Commission to have some meetings of the board of directors of the Panama Railroad Company on the Isthmus, but my colleagues did not agree with me about it.

Senator MORGAN. Taking everything together, I suppose the Panama Railroad was about the most important active factor in the doing of the work of the canal, or the most indispensable?

General DAVIS. Oh, yes, quite so; it is indispensable to carrying on the canal work.

Senator MORGAN. So that the control of that railroad company had a very important influence on the work?

General DAVIS. It is bound to have, and always will have while the work lasts.

Senator MORGAN. While you were there was there any jam—

General DAVIS. Congestion of freight?

Senator MORGAN. Congestion of freight, yes.

General DAVIS. Nothing very serious during my time, but just after I left, just about the time I was leaving, and just after I left, there was a very large accumulation of tools and machinery and lumber sent down from the United States to the Isthmus for canal purposes, and the wharf accommodations had not yet been enlarged, so that it could be conveniently handled, and just during the latter part of my stay there this freight congestion began.

The Panama Railroad Company didn't have adequate rolling stock to handle the freight, to handle this very largely increased quantity of freight, they did not have wharf room to take this rolling stock, their engines were not of sufficient power to handle the heavy trains, their sidings were not long enough so that they could shunt as many cars as might be necessary, the terminal facilities were not adequate for this very large increase of the arrival of commodities, and this congestion had begun when I left there.

Senator MORGAN. Was that congestion due in any part, and if so to what probable extent, to any increase of the commerce across the Isthmus?

General DAVIS. I do not think that very much of it related to increased commerce across the Isthmus, but the congestion was brought about by the fact that the Government was becoming a very large customer of the Panama Railroad, and its facilities were not sufficient—

Senator MORGAN. Brought about by the demand of the Government for material—

General DAVIS. Yes; I think that even during my time it had happened that a train of cars would be loaded up and goods consigned to some point at which there were not facilities to receive them, and that that train of cars would stay three weeks loaded on the tracks before it was finally unloaded. I have been told this by persons connected with the train service, the difficulty being to find a place to store the stuff when it should be unloaded, or let it be thrown out into the open air, so that the most valuable agency for moving this freight was simply used as a storehouse—these box cars. Of course that did not work advantageously, but that was very soon cured.

Mr. Shonts got experienced railroad men and put them in charge of the train service, transportation men, who were thoroughly up in all those matters, and while the congestion has continued off and on since, from various causes, as I read in the newspapers, yet I think that the steps taken to relieve the congestion are the best that could be taken. So far as I know, they are. I understand that the coffee crop this year is a very large one, and that it is even now considerable trouble to transfer that coffee as rapidly as it arrives on the Pacific side. Most of

it is going to Hamburg and Havre or London. It goes out by those foreign steamers.

Senator HOPKINS. From what countries?

General DAVIS. Guatemala, Salvador, and Costa Rica.

Senator MORGAN. I suppose the chief of the sanitary corps is Doctor Gorgas?

General DAVIS. Yes; an excellent man.

Senator MORGAN. His undertaking was a very heavy one?

General DAVIS. Yes.

Senator MORGAN. To get hospitals there, and so on?

General DAVIS. Yes; it was.

Senator MORGAN. Was disease prevalent when you were there?

General DAVIS. Not especially so when we arrived there. I believe we found out afterwards that there was one case of yellow fever when we arrived; but we did not find it out until several months afterwards. I think the first case of yellow fever occurred early in July.

Senator MORGAN. I understand yellow fever is not the greatest enemy there.

General DAVIS. No; malaria is the troublesome disease, and tuberculosis kills more people than any other disease.

Senator MORGAN. I suppose from exposure to the weather?

General DAVIS. Yes; and inadequate nutrition and a bad scale of living. Tuberculosis does more harm in the Tropics than any other disease, according to my observation.

Senator MORGAN. And next to that comes malaria?

General DAVIS. Next to that comes malaria. In the Philippines they have dysentery, but in Panama there is no dysentery at all, strange as it may seem.

Senator MORGAN. None at all; no dysentery?

General DAVIS. Hardly any dysentery on the Isthmus, while in the Philippines it is very prevalent. It causes a great deal of invaliding home of our soldiers.

Senator MORGAN. And no yellow fever in the Philippines?

General DAVIS. None at all; never a case.

Senator MORGAN. And none in Hawaii?

General DAVIS. No.

Senator MORGAN. And none in Nicaragua?

General DAVIS. None in Nicaragua. I think they have had plenty of yellow fever at Greytown in times past, in former years.

Senator MORGAN. We have had testimony here that there were no cases at Greytown except those imported there for sanitation.

General DAVIS. There is more or less yellow fever up and down the Central American coast. I don't think any certain place on that coast can be counted on as entirely free from yellow fever, provided non-immune people are there. The natives are generally immune; but if there are a lot of nonimmunes there you may be sure that you will find yellow fever if it is in the country.

Senator ANKENY. Is it true, General, that you have double tracked that road?

General DAVIS. I have heard by reading what others have said that it has been double tracked through about two-thirds of its length, and I think that is about all they intend to double track at present. I only know that by reading, however. When I left there in May, 1905, they were then double tracking the road—had begun the work.

When I was there in September last year they had double tracked considerable stretches of it, but I am told now that double tracking has gone on until they have got about one-half, quite one-half, of it double tracked.

Senator MORGAN. General, during the time you were governor of the Isthmus and one of the Commissioners, which was about a year, was it—

General DAVIS. About a year, yes.

Senator MORGAN. What part of your time were you absent from the Isthmus?

General DAVIS. I was in the United States two weeks in August, 1904.

Senator MORGAN. That was on account of family bereavement?

General DAVIS. It was on account of such an occurrence as you say.

Senator MORGAN. You remained on the Isthmus at work during all the balance of the time?

General DAVIS. Yes, sir.

Senator MORGAN. Were the Commissioners there with you?

General DAVIS. They were there, five members of the Commission, five of my colleagues were there from the 30th of July, 1904, until the 6th of September of the same year.

Senator MORGAN. They were there continuously?

General DAVIS. Yes, sir; and two other members of the Commission came down again in February—members of what we called the engineering committee of the old Isthmian Canal Commission. I refer to Messrs. Burr and Parsons. They remained on the Isthmus, as near as I can now recollect, about two weeks. Mr. Hecker went down one week later than I did. He was a member of the Commission. He remained with me there until the Commission arrived, and then he returned to the United States with it, and shortly afterwards sent in his resignation.

Senator MORGAN. The minutes of this Commission, as recorded here and reported to the President and by him to Congress, show a large number of meetings. Do you recollect the number?

General DAVIS. I have an impression that it is eighty-five, but I can not say exactly. You can see in a moment by looking.

Senator MORGAN. Yes; I can get the number. They appear to have been on nearly consecutive days.

General DAVIS. Almost; sometimes day after day, right along.

Senator MORGAN. While the Commissioners were there, I take it from the character of their proceedings and work, they were very continuously employed.

General DAVIS. I think so. They were industrious. So far as I know, when they were on the Isthmus, they met every day, and on one or two occasions they met at night in my quarters.

Senator MORGAN. And you had to consult about the development of a new situation there in every respect?

General DAVIS. In every respect: yes, sir.

Senator MORGAN. Physically and in a governmental sense?

General DAVIS. Yes.

Senator MORGAN. And for the preservation of the health?

General DAVIS. Yes.

Senator MORGAN. And for your connection with outside communication for getting materials, etc.?

General DAVIS. Exactly.

Senator MORGAN. Acquiring labor, and all that?

General DAVIS. Yes, sir.

Senator MORGAN. That was a task that occupied the Commissioners individually and collectively, you may say, continually?

General DAVIS. Oh, yes; I think they were very industriously employed in all those matters. I judged so from reading their minutes, and I know what occurred when I had the good fortune to be present.

Senator MORGAN. Was there, within your knowledge, any delinquency on the part of any Commissioner during that period of time?

General DAVIS. I do not think so.

Senator MORGAN. In the performance of his duties?

General DAVIS. I do not think so, sir; but it is the superior officer who ought to judge of those things.

Senator MORGAN. He has a right to judge, but he ought to judge justly.

General DAVIS. I thought they were industrious and attentive to their duties. I felt so.

Senator MORGAN. Can you account for this statement in an order of the President, addressed to the Secretary of War, dated "White House, Washington, D. C., April 1, 1905:"

"The practical result of the operations of the Isthmian Canal Commission appointed and acting under previous Executive orders has not been satisfactory and requires a change in the personnel of the Commission and in the instructions for its guidance."

Are you aware of any fact which required a change in the personnel of the Commission?

Senator HOPKINS. One moment, Senator. That question, it seems to me, ought not to be asked of this man. He has admitted that the committee were up here while he was down there. What led the President to indite that letter may have been things that occurred up here, a thousand or 2,000 miles away from this man.

Senator MORGAN. He has stated that the Commission were there about eighty days in session.

Senator HOPKINS. That is only a small part of the period that he was a member of the Commission, and it seems to me that that question does an injustice to the General.

General DAVIS. I could not answer that question without commenting upon the action of the President of the United States, and I should think that I ought not to do that.

Senator HOPKINS. Yes; and you have not sufficient information.

General DAVIS. I have not information, either.

Senator MORGAN. Did you, while you were there, discover any delinquency or any want of attention to duty on the part of any of your colleagues?

General DAVIS. No delinquency; no, sir. I urged my colleagues to appoint an executive committee to share this responsibility on the Isthmus. I urged them in an official way; I offered a resolution at a meeting of the Commission for the appointment of an executive committee of three members who should permanently stay on the Isthmus and be associated with me in the administration of the duties which were devolved there. I do not mean that they should be associated with me in the duty as chief executive, but as a working body of the Commission, an executive committee.

My colleagues did not agree with me on that proposition. I think that was a mistake. I do not call that a delinquency; it was simply a difference of opinion. I think it would have been better if they had sent an executive committee there of their own number with power to act. But it is only an opinion, and their opinion is as good as mine. They did not agree with me. The records of the minutes will show the resolution which I offered. It is all printed.

Senator MORGAN. Do you know of any fact that shows or tends to show that any retardation of the work took place in the Isthmus in consequence of the want of industry or the want of capacity or the want of fidelity on the part of any of the Commissioners?

Senator HOPKINS. I submit, Mr. Chairman, that that is a question that ought not to be propounded to this witness. It involves practically the same objection that I urged to the previous question. The President's letter stands for what it is worth. This witness of course was not in a position to see and judge of all the things that came to the attention of the President, and he ought not to be required to put up his judgment against the President's on a matter like that, where his observation is limited, and his information is limited.

Senator MORGAN. I did not ask him for his judgment about anything at all. I asked him for the fact as to whether he saw any inefficiency or neglect of business on the part of any Commissioner while he was there.

Senator HOPKINS. But he does not know the fact.

(By direction of the committee the stenographer read aloud the pending question.)

Senator HOPKINS. You see, he has stated that for a year he was away from the Commission.

The CHAIRMAN. It seems to me it is hardly a proper question, Senator, for this witness to answer. The Commission was here at the time.

Senator MORGAN. I do not ask General Davis this question with a view of his vindicating himself, because the record vindicates him in every possible particular. I ask it with a view of the vindication of his colleagues. I would not ask him the question if it related to his own personal opinion of what his own conduct had been.

The CHAIRMAN. I do not see any reason why the witness should answer that question.

Senator MORGAN. Some of these gentlemen are before us for confirmation, and I will give the committee to understand that I want to know how they have been behaving themselves.

The CHAIRMAN. The General has signified that they behaved themselves all right.

Senator MORGAN. But the Senator does not want his answer to go down.

Senator HOPKINS. I do not want it to go down because I think it would be an injustice to General Davis, and also because it is a question that, from the standpoint of the President, ought not to be gone into with the lack of information which the witness has stated that he has, and he ought not to be put in a position either to confirm or to antagonize his superior officer on a proposition like that.

Senator MORGAN. If General Davis had said that he did not feel that he ought to make an answer to such a question as that I would

have waived it. He answered the question that he had not seen any delinquency or anything of the kind, vindicating his colleagues in a way that I am very much pleased with.

General DAVIS. I am willing to make one statement in connection with that letter which may have some bearing upon it.

The CHAIRMAN. Proceed, General.

General DAVIS. I think that my opinion would not be conclusive on the subject at all. The superior, the President of the United States, is surely to decide for himself as to the suitability of his agents for doing his work. He has expressed himself on this subject; and I am perfectly willing to concede that the President must have exactly that power that he has expressed in the few lines that Senator Morgan has read. He could not be the Chief Magistrate of this nation without the right to exercise that power.

Senator MORGAN. I do not object to his exercise of such power as that; but as a Senator, acting upon the confirmation of the same men that he had in office at the time, and some of whom he turned out, I have a right to know.

Senator HOPKINS. I think, in addition to the other propositions, that it is unfair to put General Davis in an attitude where he might or might not antagonize the position of the President.

Senator KITTREDGE. I do not think this question is in line with the question to which you objected just prior to this.

Senator DRYDEN. I think, Mr. Chairman, that the committee should remember that General Davis occupies a different position from many of the other witnesses that have appeared before us. He is an officer of the Army; and anything which requires of him a statement which either directly or indirectly reflects upon his superior officer, namely, the President of the United States, I think should be excluded.

Senator KITTREDGE. I do not understand that this question amounts to that.

Senator HOPKINS. The question was seeking to antagonize him in his statement with that of the President. That was the apparent object of the question. I do not know whether the questioner intended that or not, but that was the effect of the question.

(By direction of the committee the stenographer again read aloud the pending question as follows:)

Do you know of any fact that shows or tends to show that any retardation of the work took place in the Isthmus in consequence of the want of industry or the want of capacity or the want of fidelity on the part of any of the Commissioners?

Senator KITTREDGE. That is quite a different question from the one asked just prior to that.

Senator HOPKINS. I do not think it is. It would be highly improper for this witness to answer it.

Senator KITTREDGE. If General Davis has any objection to answering that question, I would be willing to vote to excuse him.

The CHAIRMAN. I think it should be left to the witness.

Senator KITTREDGE. Otherwise not.

Senator HOPKINS. I do not think so, Mr. Chairman. I think that is a matter that is part of our province.

Senator TALIAFERRO. That question could have been asked with absolute propriety if the President had never written a line on the subject. The question is whether this witness, as a member of the

Commission and as governor of the Zone there, and as this Government's agent, practically, on the Isthmus, knew of anything connected with the conduct of these other agents of the Government that had in any way put back that work on the Isthmus. That is the question.

Senator HOPKINS. That would be all right enough if the President had never expressed himself on the subject. Then this witness, in whatever answer he might make, would not be putting himself in antagonism with his superior officer or taking any position whatever with reference to him. But inasmuch as the President has written what has been read by Senator Morgan, it does become a pertinent question as to whether this witness should be put in an attitude of contradicting or criticizing his superior officer. Then, in addition to that, Mr. Chairman, he has already shown that these men were here in Washington and that he was there on the Zone, so he has not the information which would enable him to answer the question.

Senator MORGAN. The President states this, if the chairman will allow me:

"The practical result of the operations of the Isthmian Canal Commission appointed and acting under previous Executive orders has not been satisfactory, and requires a change in the personnel of the Commission and in the instructions for its guidance"—the practical results of the work done on the canal and elsewhere in the performance of their duties.

Senator HOPKINS. I disagree with the Senator.

Senator MORGAN. We have examined the whole of that work there, both there and here, freely and with perfect right on our part, at least—for I do not think I have any superior officer when I am required by the Senate to ask a question that I think is proper for its information; and I predicate my question upon what the President asserts is the practical result of the operations. We have that. Now I want to know of the witness whether he is aware or has any reason to suspect that the practical results of the operations there of which the President complains have been the fault, within his knowledge, of any member of the Commission. I want to show that the fault is in the situation.

Senator HOPKINS. Now, Mr. Chairman, you can see that that question of itself does not elucidate any proposition that this committee is called upon to pass upon or to recommend to the Senate—not at all. It is simply an effort upon the part of the questioner to antagonize this witness with his superior officer; and it is asking him a question, as I have before said, that covers a subject that he does not know any more about than a schoolboy, because he was down there discharging his duties efficiently while these men were up here. He is not supposed to know, and does not know, what information the President had that caused him to write that letter.

Senator KITTREDGE. The question simply calls for his own knowledge. If he has not any, he can say so.

Senator HOPKINS. I think the chairman had better rule on the question.

Senator TALIAFERRO. I do not agree with you, Senator, that there is any purpose on the part of Senator Morgan to bring this witness in antagonism with or in criticism of the President. If I thought so I would not favor the answers being given. But you assume to take care of a witness here who has shown that he is abundantly able to

take care of himself; and I take it that General Davis is not going to be drawn into any antagonism of the President by any question that is put to him.

Senator HOPKINS. I think the best way is not to let the question be answered, because it is not pertinent to anything that we are considering here.

The CHAIRMAN. I see no reason why the witness should be called upon to answer this question unless he desires to do so. The chair will excuse him if he desires to be excused.

Senator MORGAN. Oh, if the General should say that he desires to be excused from it, that is another matter.

General DAVIS. It would be the height of impropriety for an officer of the Government holding the relation to the Commander in Chief of the Army and Navy that I necessarily hold to pass any opinion whatever of approval or disapproval on his action. It would be the height of impropriety. I have been forty years and more in the service, and it would be entirely wrong. I do not know what was in the mind of the President when he wrote that paragraph. It is impossible that I should. He had means of knowledge which I did not possess. He could know of events that were unknown to me, and I feel as if it would be quite improper for me to discuss this subject.

The CHAIRMAN. Senator Morgan, will you proceed with other questions?

Senator MORGAN. I want to state one of the grounds upon which I ventured to ask this very tender question. That letter is dated April 1, 1905, at the time of the organization of the new Commission. The President says, in a message to Congress dated January 8, 1906:

"The work on the Isthmus is being admirably done, and great progress has been made, especially during the last nine months. The plant is being made ready and the organization perfected."

I want to show that as much progress had been made during the preceding time as had been during the last nine months, and a great deal more, and I will show it, and have shown it. [Reading:]

"The first work to be done was the work of sanitation, the necessary preliminary to the work of actual construction; and this has been pushed forward with the utmost energy and means. In a short while I shall lay before you the recommendations of the Commission and of the Board of Consulting Engineers as to the proper plan to be adopted for the canal itself, together with my own recommendations thereon. All the work so far has been done not only with the utmost expedition, but in the most careful and thorough manner; and what has been accomplished gives us good reason to believe that the canal will be dug in a shorter time than had been anticipated and at an expenditure within the estimated amount."

I suppose we are at liberty to show that the President was mistaken in that declaration to us. I think we are not debarred, because he says a thing, from inquiring into whether or not the foundations of fact on which he made that expression of opinion are correct.

Then he goes on to say, after speaking of certain accusations and the sources from which they sprung, that they emanate from men who are "desirous of obtaining notoriety by widespread slander. More often they originate with or are given currency by individuals with a personal grievance. * * * Every specific charge relating to jobbery, to immorality, or to inefficiency from whatever source it has come has

been immediately investigated, and in no single instance have the statements of these sensation mongers and the interested complainants behind them proved true. * * * I court the fullest, most exhaustive, and most searching investigation of any act of theirs," which includes their employees down there, "and if any one of them is ever shown to have done wrong his punishment shall be exemplary."

Senator HOPKINS. Senator, there is nothing inconsistent in that statement that he has sent to us and the statement upon which you predicated your question to General Davis. There is no inconsistency on the part of the President there.

Senator MORGAN. The Senator is defending the President against an alleged inconsistency that has not been even hinted.

Senator HOPKINS. I am not defending him at all; but you are reading that as a basis for the justification of your question, and I, without defending the President (because he does not need any defense) am saying that there is no inconsistency between what you are now reading and the statement that you read upon which you predicated your questions.

Senator MORGAN. I am trying in this manner simply to ascertain what has been done, and if there is anything that has been omitted to be done by any person who is in default to ascertain that and point it out; because the President demands the most thorough investigation of every person who has been engaged in that work there, and I supposed that he meant what he said. If anybody here has a right to say that he was not in earnest about it, let him speak up and say so.

I will not press the question upon General Davis, because he has evinced a disposition, which I think is very highly commendable, not to criticise in any possible sense his superior officer in the Army; though I think that around this board we are all civilians.

General Davis, have you ever known any person who was a stockholder in the New Panama Canal Company at any time?

General DAVIS. I have no personal acquaintance with any individual that I know to be a stockholder. I never saw a list of the stockholders of the New Panama Canal Company; I never saw a list of them in my life. I presume I have met people who were stockholders, but I did not know it, and do not know it now.

Senator MORGAN. Did you know it from anything they said to you?

General DAVIS. No; I have no recollection of anything said to me that would indicate that any of the persons I was talking with were stockholders.

Senator TALIAFERRO. Does that apply also, General Davis, to bonds?

General DAVIS. To bondholders of the New Panama Canal Company?

Senator MORGAN. There were not any bonds issued?

General DAVIS. There were not any bonds.

Senator TALIAFERRO. By the New Panama Canal Company?

Senator MORGAN. The Old Panama Canal Company issued bonds?

General DAVIS. No; I do not think—I can not recall now that I ever was acquainted with anybody that I knew to be an investor in the Old or New Panama Canal Company, although I presume that I have met such people without knowing it.

Senator MORGAN. While you were governor you made a report of which I have what I conceive to be an incomplete copy, or, I might

say, a corrected copy—an altered copy. I wish to hand it to you and ask you to look at it and see whether you recognize that document.

General DAVIS. I recognize this paper as a retained copy of a report that I made to the chairman of the Isthmian Canal Commission on, I think, the 1st day of October, 1904. It is in the nature of an annual report of certain transactions that came to my knowledge as governor of the Canal Zone. The original sent forward was an exact copy of so much of this as is in typewriting. There are a few places in which I have made changes in pencil. Those were to note corrections that I would have made in the original if it had remained in my hands so that I could do so.

Senator MORGAN. I find some papers referred to in that document that are not copied. If you will hand it to me a moment, I will call your attention to them. One of them, I remember, is a letter from Mr. De Obaldia.

General DAVIS. Yes, sir; the letter was one from the minister of the Republic of Panama, addressed to the Secretary of State of the United States at Washington, and had for its date probably June, 1904. I am not quite sure about its date now. A copy of it was handed to me by the minister of the United States resident at Panama, Mr. John Barrett; and it was the paper that I used in the preparation of this report. I made frequent citations from it in that document. I have looked over my retained papers, and this is a copy of the original letter.

Senator MORGAN. From Mr. De Obaldia?

General DAVIS. From Mr. De Obaldia to Mr. Hay, which was given to me by Mr. Barrett, and which I think has been printed in the newspapers of the Republic of Panama. I think it has been given to the public. I found it in my file after the secretary of the Isthmian Canal Commission had made an inquiry of me in furtherance of a request made upon him by Senator Morgan as to what document Senator Morgan's request related to; and then I looked up what I had in the way of further information. I find this paper among them. It is a letter dated "Legation of Panama, Washington, August 11, 1904," and is addressed to the Secretary of State of the United States. As I said before, I think it was printed in the newspapers of the Republic of Panama. Whether it has been given to the public here by our Government or not I do not know. It is a document that came into my possession in the way I state.

Senator MORGAN. I will ask you, General Davis, whether the reports that you have made to that Commission have all been published in full, or whether they have been published in part and suppressed in part?

General DAVIS. The annual report as governor of the Zone which I made, I think, on the 1st of October—I think it has a concurrent date with the document you have before you—was forwarded in manuscript to the Commission; and a part of it was extracted and sent to me in manuscript form, with the statement that this part was what the Commission proposed to print of the report that I had written. As they had segregated the document and left out about half of it, I felt that they were not treating me fairly in the matter, and called the attention of the Secretary of War to the mutilation, as I called it, of that report. He himself directed that a large part of the remainder should be published, which has been published since, and is marked "Supplementary Report of General Davis."

Senator HOPKINS. But certain parts of it have not been published? General DAVIS. A few pages only have not been—a few pages.

Senator MORGAN. So that your report as you made it has not been fully published, although it professed to have been fully published?

General DAVIS. This report that I made has been printed in full, except about two pages—two foolscap pages of no especial importance. But it contained an appendix made up of a large number of documents—that map, that map, and this map [indicating maps in committee room], and a copy of the provisional agreement for the delimitation of the Canal Zone, which I have here, and a good many other documents, thirty or forty, as an appendix, so that the original might be explained. None of those appendices have been printed.

The CHAIRMAN. Senator Morgan, it will take you some little time, I suppose, to finish. Would you be willing to take an adjournment now until, say, 2 o'clock on Monday, or did you wish to proceed with this examination now? It is 5 o'clock, and I think perhaps we had better take an adjournment.

Senator MORGAN. I do not know about 2 o'clock on Monday.

The CHAIRMAN. I did not know how long you would be.

Senator MORGAN. To-morrow is a day that the committee ought to be at work, I think, as there is no session of the Senate.

The CHAIRMAN. If it is agreeable to the committee to meet to-morrow afternoon, it will be entirely agreeable to the chairman. I have a matter in the morning that will prevent my being here, but I can be here at any time after 12 o'clock to-morrow.

General DAVIS. There is just one thing that I happen to think of now that I would like to say in this connection. I spoke to Mr. Taft about coming before the committee, as I was told that I was to come in respect to these matters of Zone government, and the Secretary said at once: "By all means explain to the committee everything about this matter of Zone administration, for I want them to know everything that you know about it—this handling of these questions in the Zone; all of these matters of discussion that occurred. Explain everything to them fully if they wish you to."

Then I also have here a document which I feel confident will be interesting to you. It has not been published, so far as I know, in America, although it was printed in Panama. That is the identical agreement that I entered into with the Government of Panama for delimitation of the Canal Zone—the identical document which has not been printed at all in the United States.

Senator MORGAN. That is a very important paper and ought to go into these records, because we do not know what the delimitation of the Canal Zone around the cities of Colon and Panama is except by reference to that document.

General DAVIS. That is a copy of the paper that I found among my retained records. It is an exact copy of the original.

The CHAIRMAN. Is there any objection on the part of any member of the committee to handing it to the stenographer?

(There was no objection.)

Senator MORGAN. That is not a part of this other report at all? They have put it in as an appendix to the report, or an exhibit?

General DAVIS. It is an exhibit, and I think it will be quite useful to you gentlemen here, for it relates to a very important matter.

Senator MORGAN. I want it by all means, because that is the only evidence we have as to what the agreement is.

The CHAIRMAN. It will go into the record unless some member of the committee objects.

General DAVIS. And the Secretary's agreement with the Government of Panama ratifying it, you know, and requiring from the Government of Panama an indorsement of it.

(The paper above referred to, which, by direction of the committee, was printed as a part of the record, is as follows:)

ISTHMIAN CANAL ZONE, EXECUTIVE OFFICE,

Culebra, June 21, 1904.

SIR: I have the honor to inclose herewith copy of the agreement relating to the delimitation of the Canal Zone recently entered into by myself as governor of the Zone with the secretary of state and the attorney-general of Panama as representing that Republic: also copy of each of three maps illustrating the boundaries of which a verbal description is contained in the agreement.

Very cloudy weather has made it impossible for us to print satisfactorily from the tracings, and I regret that the maps are in the condition they are, but later on better copies will be forwarded.

Copies of these maps have also been forwarded to the Chief of Staff of the Army.

Respectfully,

GEO. W. DAVIS,
Governor.

The SECRETARY OF WAR,
War Department, Washington, D. C.

Whereas by the terms and provisions of Article II of the Convention for the Construction of an Interoceanic Canal between the United States of America and the Republic of Panama, signed by the representatives of the two nations on November 18, 1903, the ratifications of which were exchanged at Washington on the 26th day of February, 1904, the United States acquired the right of use, occupation, and perpetual control from and after the said 26th day of February, 1904, in and over the Canal Zone and other lands, waters, and islands named in said Article II of the convention aforesaid; and

Whereas it has not yet been, and is not now, practicable to make a complete, definite, and exact location of the precise boundaries of all the territory ceded to the United States by the terms and provisions of said Article II of said convention; and

Whereas the successful completion of the work of construction of the Interoceanic Canal across the Isthmus of Panama is of transcendent importance to the United States, to the Republic of Panama, and to the people of the world; and

Whereas in order that said work of construction of said interoceanic canal may be systematically prosecuted, and in order that a government for the Canal Zone created by the terms and provisions of said Article II of said convention may be successfully organized and carried forward, it is necessary that the extent and boundaries of the territory ceded to the Government of the United States by the Gov-

ernment of the Republic of Panama under the terms and provisions of said convention shall be provisionally determined and agreed upon.

Now, therefore, General George W. Davis, governor of the Panama Canal Zone, acting for and on behalf of the Government of the said Zone, and Señor Don Tomas Arias, secretary of state of the Republic of Panama, and Señor Don Ramon Valdes Lopez, attorney-general of said Republic, jointly acting for and on behalf of the Government of said Republic of Panama, having agreed that the Government of the Republic of Panama has delivered, and the Government of the United States has received, and had, on the 19th day of May, 1904, received, for its use, occupation, and control, the Isthmian Canal Zone described in said Article II of the aforesaid convention for the construction of an interoceanic canal, including lands and waters in the said Zone, lands under water, islands in said Zone, and the islands of Perico, Naos, Culebra, and Flamenco, do make this further agreement:

SEC. 1. The limits of the Canal Zone, including lands under water and islands ceded, but not including the cities and harbors of Colon and Panama, delivery of which lands, waters, and islands has been made by Panama, and possession of which has been taken by the United States, are indicated and shown on the attached map (marked "A"), signed by the parties to this agreement, as accurately as it is possible to indicate on a map with the existing information respecting the topography of the region traversed by the canal, by a heavy red line crossed with black, and drawn at the uniform distance by scale of five (5) statute miles on each side of the middle line of the canal, and said indicated boundary, or line of division, between the territory ceded by the Republic of Panama to the United States for canal purposes and the adjoining or abutting lands of the Republic of Panama is provisionally accepted, and will be strictly observed by the two Governments until the limits or boundaries of the said Zone, waters, and islands shall be definitely and finally marked, fixed, and determined.

SEC. 2. The limits of the city and harbor of Panama, as indicated and shown by a heavy red line crossed with black on the attached map (marked "B"), and as described on the paper attached to the said map, both of which are signed by the parties to this agreement, are provisionally accepted and will be strictly observed by the two Governments until the true and definite line of division between the Canal Zone and its waters, on the one hand, and the city of Panama and its harbor, on the other, shall be finally surveyed, marked off, fixed, and determined: *Provided*, That the outer or marine boundary of the harbor of Panama shall, as soon as practicable, be agreed upon and marked with buoys or other monuments.

SEC. 3. The limits of the city and harbor of Colon, as indicated and shown by a heavy red line crossed with black on the attached map (marked "C"), and as described in a paper attached to said map, both of which are signed by the parties to this agreement, are provisionally accepted and will be strictly observed by the two Governments until the true and definite line of division between the Canal Zone and its waters on the one hand and the city of Colon and its harbor on the other shall be finally surveyed, marked off, and determined.

SEC. 4. As necessity may arise special agreements will be made and entered into from time to time by the parties hereto or by their successors respecting the delimitation of any auxiliary lands or waters

outside the Canal Zone which may be found to be necessary or convenient to the construction, sanitation, or protection of the inter-oceanic canal or of its auxiliary works.

SEC. 5. The governor of the Canal Zone or his successors may employ the citizens of the Republic of Panama residing in the territory of the Republic, for which purpose the Government of the Republic gives them the permission mentioned in paragraph 2 of article 7 of the national constitution.

In witness whereof we have signed these presents in the city of Panama, this — day of June, 1904.

(Signed) GEORGE W. DAVIS,
Governor Canal Zone.

(Signed) TOMÁS ARIAS,
Secretary of State Republic of Panama.

(Signed) RAMÓN VALDÉS LÓPEZ,
Attorney-General Republic of Panama.

A true copy.

GEO. W. DAVIS,
Governor Canal Zone.

Provisional delimitation of boundaries between the territory of the United States of America on the Isthmus of Panama, known as "The Panama Canal Zone," and the city and harbor of Panama, in the Republic of Panama, being the delimitation to which reference is made in the agreement entered into between the government of the said Canal Zone and the Government of the Republic of Panama, signed by General George W. Davis, governor of the said Zone, on behalf of the said government of the Canal Zone, and by Señor Don Tomas Arias, Secretary of State, and by Señor Don Ramon Valdes Lopez, attorney-general, on behalf of the Government of the Republic of Panama, as follows:

Beginning on the shore line of the Pacific Ocean at a stake driven above high-water mark on Punta Paitilla, thence on a straight line northwesterly to a similar stake driven upon the summit of Cerro Pelado, which hill is situated on the south side of the Savanna road, said stake being about eighteen hundred (1,800) metres northeast from the Caledonia Bridge; thence on a straight line to a similar post driven on the summit of Cerro Corundu; thence on a straight line to a similar stake at the southeast corner of the tract of land known as Le Section and upon the north side of the hospital road; thence on a straight line crossing the road leading from Panama to the hospital across the meadows and fields to a similar stake driven on the north side of the road leading from Panama to La Boca, about seventy-five (75) metres from the old walled spring Chorillo; thence southwesterly in a straight line across La Boca road to a similar stake driven at high-water mark upon Punta Mala, near the islet of Gabilan.

At each of the stakes above mentioned and at each of the other calls above given for the purpose of marking the boundary in question there shall be set a masonry monument about one (1) metre square and one (1) metre high, and in the center of the masonry and projecting about sixty (60) centimetres above it shall be placed an iron

column or post marked on the side of the Canal Zone with the letters U. S. and on the opposite side with the letter P.; all of said letters to be about six (6) centimetres in height, these monuments to be erected as soon as practicable at the expense of the United States.

(Signed) GEORGE W. DAVIS,
Governor Canal Zone.

(Signed) TOMÁS ARIAS,
Secretary of State Republic of Panama.

(Signed) RAMÓN VALDÉS LÓPEZ,
Attorney-General Republic of Panama.

Professional delimitation of boundaries between the territory of the United States of America on the Isthmus of Panama, known as "The Panama Canal Zone," and the city and harbor of Colon, in the Republic of Panama, being the delimitation to which reference is made in the agreement entered into between the government of the said Canal Zone and the Government of the Republic of Panama, signed by General George W. Davis, governor of the Canal Zone, on behalf of the government of said Zone, and by Señor Don Tomas Arias, secretary of state, and Señor Don Ramon Valdes Lopez, attorney-general, on behalf of the Government of the Republic of Panama, as follows:

The city of Colon: All that portion of the island of Manzanillo which is above low water, except the tract of land reclaimed from the sea and generally known by the name of La Terre Plein de Crostobal Colon, and the boundary between said La Terre Plein and said city is as follows:

Beginning at a point on the northern shore line of Boca Chica, sometimes called Folks River, said point being fifty (50) metres to the eastward of the middle of the main line of track of the Panama Railroad; thence northward and northwestward, always parallel with the said railroad track and at a uniform distance of fifty (50) metres from the middle line thereof, to the middle line of Bolívar street (sometimes called C street); thence along the middle line of said Bolivar street to the middle line of Eleventh street; thence along the middle line of Eleventh street to low-water mark on the shore of the harbor of Colon.

The harbor of Colon: All that portion of said Limon Bay lying westward of said city of Colon and northward of a straight line drawn from the center of the existing monuments of Cristobal Colon, true west to the westerly shore of Limon Bay: *Provided, however,* That the entrance channel of the Panama Canal through said harbor of Colon to its southern boundary, of the width of three hundred and thirty (330) meters on either side of the middle line or axis of said entrance channel wherever said channel may now or hereafter cross the same, is hereby declared to be a part of the Canal Zone, under the exclusive jurisdiction and control of the United States, the limits of said channel through said harbor to be suitably marked by buoys or otherwise: *And provided further,* That the said Terre Plein between the said monument of Cristobal Colon and the middle line of Eleventh street extends to low water.

There are excepted from the city and harbor the existing light-house on Manzanillo Island, and all land lying within thirty (30) metres thereof, these being within the Canal Zone.

(Signed) GEORGE W. DAVIS,
 Governor Canal Zone.

(Signed) TOMÀS ARIAS,
 Secretary of State Republic of Panama.

(Signed) RAMÓN VALDÉS LÓPEZ,
 Attorney-General Republic of Panama.

(Thereupon, after an informal discussion, the committee adjourned until Monday, April 2, 1906, at 2 o'clock p. m.)

ISTHMIAN CANAL.

COMMITTEE OF INTEROCEANIC CANALS,
UNITED STATES SENATE,
Washington, D. C., Monday, April 2, 1906.

The committee met at 2 o'clock p. m.

Present: Senators Millard (chairman), Kittredge, Hopkins, Morgan, and Taliaferro.

STATEMENT OF MAJ. GEN. GEORGE W. DAVIS, U. S. ARMY, RETIRED—Continued.

Senator MORGAN. General Davis, at our last meeting we were discussing the question of a report that you had made to the Isthmian Canal Commission, of which you were then a member, and a letter of Mr. De Obaldia, who was then minister of foreign affairs, I believe, in Panama.

General DAVIS. In Washington.

Senator MORGAN. He was minister from that Government to this?

General DAVIS. Yes, sir.

Senator MORGAN. At that time?

General DAVIS. Yes, sir.

Senator MORGAN. Have you that letter?

General DAVIS. Yes, sir; a copy of it.

Senator MORGAN. This report of yours was made to inform the Commission and the Secretary of War of all the circumstances and conditions under which you conducted the preliminary negotiations with the Government of Panama by direction of the President?

General DAVIS. Well, in a letter of the President, addressed to the President of the Republic of Panama, given to me before I sailed for the Isthmus, there was a request expressed by the President to the chief executive of the Panama Republic that he should discuss with me all matters respecting the work that the two nations were so much interested in, and it also contained the phrase that he was sending me there as governor, and he wished the President of Panama to regard me as his, our President's, personal representative.

Senator MORGAN. As his personal representative?

General DAVIS. Yes, sir. That language was used in the letter.

Senator MORGAN. Had we a minister at Panama at that time?

General DAVIS. We had a minister at Panama, but he had not yet reported.

Senator MORGAN. I mean, there was no minister at Panama?

General DAVIS. No; there was a chargé there.

Senator MORGAN. And you really took his place in these preliminary negotiations?

General DAVIS. I should scarcely say that I took his place, but I felt entirely competent to discuss with the Government of Panama any questions that might be necessary.

Senator MORGAN. By "competent" you mean authorized?

General DAVIS. Authorized; yes, sir.

Senator MORGAN. And this report that you made embodies the transactions and communications that you had with that Government?

General DAVIS. It does.

Senator MORGAN. Under that authority?

General DAVIS. Yes; it embodies a sketch of it. It does not pretend to give every detail of the negotiations.

Senator MORGAN. But it is your report of what you did?

General DAVIS. Yes, sir.

Senator MORGAN. And you consider it a full report?

General DAVIS. Yes, sir; it is a full statement.

Senator MORGAN. I want, Mr. Chairman, to have this report printed, along with the letter of De Obaldia, as an appendix to the testimony of General Davis.

The CHAIRMAN. I do not understand that there is any objection on the part of any member of the committee, and therefore that will be done.

Senator KITTREDGE. May I ask one question here, Senator?

Senator MORGAN. Yes.

Senator KITTREDGE. Did you, while governor of the Zone, investigate the question of customs duties and the revenues of the Government?

General DAVIS. I considered them, and of course that involved investigation; as my functions were confined to those of carrying out the instructions of the President, and they involved the maintenance of government, and as taxation was one of the functions of government, of course the investigation of those subjects was an important one, and I would answer, "Yes."

Senator KITTREDGE. Was the result of your investigation included in that report?

General DAVIS. It is very often referred to; and in the annual report that I made at the end of the year you will find the statement of all revenues collected.

Senator KITTREDGE. Has that report been published in full?

General DAVIS. Oh, yes. It has all been published excepting a matter of a page or two that we were talking about here the other day, which is of no consequence.

Senator MORGAN. You insist upon that being of no consequence, and I insist that it is of consequence. I want it to go in your report when it is printed.

General DAVIS. That, Senator, is another report from this.

Senator MORGAN. I know.

Senator KITTREDGE. Have you reduced your views to writing in any other manner upon this subject I have mentioned except as you have stated them in the reports?

General DAVIS. On the subject of taxation and revenue?

Senator KITTREDGE. Yes.

General DAVIS. No, sir. Those two reports that I made contain all that I have written on the subject.

Senator KITTREDGE. They cover your views fully?

General DAVIS. Yes; they cover them fully.

Senator TALIAFERRO. You spoke of two pages being omitted from this other report—this second report you have referred to?

General DAVIS. Yes, sir.

Senator TALIAFERRO. How does it come that two pages were omitted from each report?

General DAVIS. I think I related to you Friday that when the report was sent to the Commission—the Commission being in session here in this city and I being on the Isthmus—the Commission, you might say, “blue penciled” the report to a very considerable extent. They left out probably about half of it, on the ground, I think, that in this report I had made I had been discussing two subjects, one of the subjects reported upon by me as governor of the Canal Zone and the other subjects of a larger nature that related to the functions and duties and responsibilities of the Commission itself; and they thought that in a report of the governor it was not necessary.—I can not say that I should use the expression not proper, although perhaps they meant to use it—to include in the report of the governor anything that was of the larger scope—that is, the subjects that concerned the Commission or myself as a member of the Commission. The part that they omitted was the part that related to the broader questions of constructing the Panama Canal.

I felt dissatisfied with the way they had left me in that respect. I felt that if I was to appear as having made a report at all, the report ought to be complete. I said to the Commission that I was content to have the whole report suppressed; that I had no objection to that; but that if the report was printed I thought the whole of it ought to be printed. They did not agree with me. I appealed to the Secretary of War, and he read the report and directed that the remainder of it, excepting the couple of pages, be printed; and it was done by his direction, and it now appears in the first annual report of mine as “Supplemental report of General Davis, governor of the Canal Zone.”

There were two or three pages omitted, and all the appendix matter was omitted, which contained the full history of this Zone delimitation and the maps which describe it—the three maps which are here now. That is one of them, that is another, and another is here [indicating].

Senator MORGAN. The two pages that were stricken out never did appear in print?

General DAVIS. No, sir; so far as I know.

Senator MORGAN. You have got those?

General DAVIS. I have.

Senator MORGAN. I will ask, if you please, that you show us that report as it was printed and the two additional pages.

General DAVIS. I have the report, but I have failed to bring with me the omitted pages.

Senator TALIAFERRO. The De Obaldia letter is also to be printed.

General DAVIS. Yes, sir; this is it here. I have had a conversation with Secretary Taft since your last meeting, and I mentioned to him this particular document, the De Obaldia letter, with which he is quite familiar, and he said he had no objection to this paper being printed, and the reply that Mr. Hay made to the De Obaldia

letter, and that he intended himself, when he came before your committee, to submit those documents.

Senator HOPKINS. If he is going to do that, we do not want it in twice.

Senator KITTREDGE. It is properly in here.

The CHAIRMAN. It properly follows in here, I think.

Senator MORGAN. General, I have here a pamphlet entitled "Isthmian Canal Commission—Sundry Technical Reports in Relation to the Panama Canal, Covering the Period 1899 to 1904, Inclusive. Compiled under the Direction of the Chief Engineer, January, 1905." Was that printed by order of the Commission?

General DAVIS. I think not. That document, as I remember, was printed on the government press at Panama, by direction of the chief engineer, Mr. Wallace. The general subject discussed in that pamphlet, you will observe, is engineering, and he collected together all those documents in Panama and had them printed about February or March, 1905. I received a copy from Mr. Wallace in Panama. After that, there were several copies sent to the Commission. The Commission, so far as I know, did not order the printing of the documents.

Senator MORGAN. Mr. Chairman, this document contains some very important papers that are put together here. I speak of them as being important in respect of the value of the information that they convey, including the report of Major Black, made to the Panama Canal Commission, I suppose.

General DAVIS. Made to Admiral Walker, who was then chairman.

Senator MORGAN. Yes.

General DAVIS. I think they were made to him while Admiral Walker was chairman of the first Commission, not as chairman of the second. At all events, some of those reports were addressed to him in his former capacity.

Senator MORGAN. This document contains the report of Monsieur Choron, chief engineer of the New Panama Canal Company; an abstract from the report presented to the council of administration of the company by the technical committee, constituted by virtue of article 31 of the statutes of the New Panama Canal Company; a possible source of water supply for Colon and Panama, by Major Black, April 2, 1904, and a statement of preliminary projects for sanitary work of Colon, formation of entrance channel to the canal and inner harbor at Colon, by Major Black; report of work done by the party under the charge of Major Black, dated April 2, 1904, which party was sent to the Isthmus in anticipation of the turning over of the property; and then the general report of Major Black, made to Admiral Walker, when Major Black concluded his work there and was relieved from duty, and a project outlined in a report of the Isthmian Canal Commission of 1899-1901, by Rear-Admiral John G. Walker, U. S. Navy, president.

All of these papers appear to be important, and this document is also accompanied with an appendix.

I move that this paper be printed, to stand as an appendix to the report of the committee that we will make to the Senate, in order to present to the Senate a condensed statement of very important facts that otherwise would perhaps be unavailable to Senators.

The CHAIRMAN. Suppose we could get a sufficient number of these to answer the requirements; would that do, or would you prefer to have it printed as a public document?

Senator MORGAN. When we make up our reports and send this great mass of papers to the Senate, this should be an appendix to that. I do not mean to put it as an appendix to General Davis's testimony.

The CHAIRMAN. I understand that.

Senator MORGAN. But as a general appendix; and I make that motion.

The CHAIRMAN. That it be printed as a document?

Senator MORGAN. Yes.

Senator HOPKINS. As a part of the hearings before the committee?

Senator MORGAN. As an appendix to the hearings before the committee.

Senator TALIAFERRO. I second the motion.

(The motion was carried.)

Senator MORGAN. The next document that follows that in historical or chronological order is the First Annual Report of the Isthmian Canal Commission, and a letter of the Secretary of War transmitting that report. I move that that be printed also as an appendix to the general report, to succeed the paper that I have just read. That preserves the chronological order of all the reports as they come up.

Senator HOPKINS. That is to be published to follow the last paper you submitted, as a part of the hearings before this committee?

Senator MORGAN. Yes.

The CHAIRMAN. There appears to be no objection, and that will be done.

Senator MORGAN. General, the other day I asked you to please furnish an answer to a question that I wrote out and handed to you. Are you prepared to do it now?

General DAVIS. I can answer it.

Senator MORGAN. I shall be very glad if you will read the question, and then answer it.

General DAVIS. I will say, as a preliminary, that to answer a question of a technical nature like this offhand is not very easy, but I have done the best I could. If the answer was to be made the basis of any action, I should wish to revise it, because I have not had time to study some phases of it, or a good many phases of it. This is the question:

"A sea-level canal from the 40-foot contour, in the Bay of Limon, hugging the hills on the right bank of the Chagres to a point about 1 mile from Gamboa, where a lock of 30-foot lift is to be built. The spoil from the canal channel to be embanked on the line next to the river, to protect against the waters of the Chagres and its affluents that enter through its left bank. This embankment to be used in connection with a drainage channel to carry off the overflow of the Chagres, when needed.

"2. A dam at Gamboa, of the dimensions given in the report of the minority of the Board of Consulting Engineers, and, connected with it, the viaduct and regulation works suggested by Menocal.

"3. The viaduct to lead into a lock with lift of 30 feet connected with it on its eastern entrance, making two locks of 30-foot lift and,

say, 1 mile apart, to connect the sea-level part of the canal with the summit level of the lock section, which will be in the viaduct and extend to Miraflores, or Pedro Miguel, where two locks, each with 30-foot lift, will connect the lock section of the canal with the sea-level canal from the point of junction out to the Bay of Panama.

"4. The drainage channel from Gamboa, to take care of the flood waters of the Chagres, will occupy the present bed of the river, where it is not taken into the sea-level section of the canal, and those parts of the present bed of the Chagres connected with each other by short diversion channels, and the canal embankments will, probably, be carried through the Gigante watershed to the swamps, and out to the sea."

In answer to that question I will say:

First, that the word "minority," where it appears in the second paragraph, is probably a misprint for the word "majority," for the minority do not propose a dam at Gamboa.

Senator MORGAN. Yes; it should be majority.

General DAVIS. The idea as I understand it is (reading):

"(a) To make the Atlantic maritime section extend to 1 mile below Gamboa, or to about the point where the sea-level canal as projected last crosses the Chagres, the channel to hug the foothills on the right bank of that stream all the way and to be shut out from the same by an embankment or levee; the first lock of 30 feet lift to be placed near mile 30, sea-level map.

"(b) To build the Gamboa dam as proposed by the majority and make it, in addition, a viaduct, to which the channel, approaching from below, would join, the regulated flow of the Chagres to be carried under the viaduct and discharge into the pool below, supposed to have been created above the lower lock close by.

"(c) To build a lock at the southern end of the viaduct with 30 feet lift, so raising the surface level to plus 60 feet.

"(d) To then carry the canal through the summit cut Culebra at level 60 for water surface, or plus 20 above sea level for bottom of canal, and lock down to the south of Culebra with two 30-foot locks, one at Pedro Miguel and one at Miraflores; the Pacific sea-level section, with width of 300 feet, to extend to the lower lock at Miraflores, which would serve as a tide and lift lock combined."

Is that a fair statement of it, Senator?

Senator MORGAN. That is a fair statement of it.

General DAVIS (continuing): "The plan does not seem to me to be a practicable one, for the following reason:

"The first or northernmost lock lift, 30 feet, would be situated just outside or on the convex side of the bend of the Chagres to the northeast of the mile mark 30. Just at mile 30 the sea-level location crosses the Chagres, and the bed of the stream at this point is a little more than 30 feet above the sea. A half mile above that point, where the same location crosses the Chagres the last time, the river bed is nearly 40 feet above the sea.

"Since the lock is to have only 30 feet lift, the water level above it in the canal will be 40 to 50 feet below the bed of the Chagres just alongside or very near.

"Having passed this lock, the bed of canal still 10 feet below the level of the sea, navigation across the line of the Chagres is to be

secured by a viaduct, its floor at the same level as the canal, but the present surface of the earth in the valley where the Gamboa dam and the viaduct are to be placed is now 50 feet above the level of the sea, or it will be 60 feet above the floor of the viaduct which is to be built alongside of and in connection with said dam. Then there are to be sluices beneath the viaduct for carrying away the regulated Chagres flow, and they are to be inclosed in masonry, according to Mr. Menocal's design, this masonry serving as viaduct floor also. The thickness of the concrete mass from the floor to the invert of the sluices is given as 16 feet, so that the bottom of the sluices will be 76 feet below the general ground surface and 26 feet below sea level; in other words, it would be necessary to excavate 26 feet into the rock for the viaduct foundation, or else the sluices would have to be sunk into the rock to that depth; and the top of the circular sluice openings would be 66 feet below the present river bed.

"It is thus made manifest, I think, that the plan proposed would not practically be realizable."

It is a technical matter, and it is rather difficult to follow, but I have tried to make it clear.

Senator KITTREDGE. This question practically contemplates what is known as the Menocal survey?

General DAVIS. I have a little more to say in respect to that matter.

Senator KITTREDGE. I thought you had finished.

General DAVIS. I have finished in answering that question. I have a little more to say on this Menocal idea; but of course, I do not want to thrust it upon you.

Senator KITTREDGE. We would be very glad to have it, General. I thought you had finished.

General DAVIS (continuing): "Menocal's idea was to cross the Chagres by a viaduct with water level at +96 feet or 66 feet above the level proposed by the question. For such a disposition of prism and levels the viaduct, considered by itself, is all right. He proposes three locks to the north of Gamboa, on the line of suggested route, always on the right bank of the Chagres, which it never crosses until Gamboa is reached."

Senator KITTREDGE. If it will not bother you, General, and you have not touched upon the question in your answer, will you indicate on the map where Menocal's three locks were? I have forgotten just where they were located.

General DAVIS. He has one lock, as I now remember, about opposite mile 28; I am not quite sure, but it is about there. He has another lock opposite Frijoles, somewhere in here [indicating on map], and his third lock is right in those hills, near Tiger Hill. Those are his three locks.

Senator KITTREDGE. That is about 3 or 4 miles from Gatun?

General DAVIS. Well, about 3 miles from Gatun, or a little less.

Menocal's line from near Gatun to Gamboa would always be in excavation, with many high spurs or ridges to cut through shown as of height above canal floor up to 235 feet. These can only be considered approximations, for we know very little about the topography away from the surveyed routes in the middle of the Chagres Valley.

"If the ground were generally level, with gentle slope all the way from Gatun to Gamboa, which it is not, a lock canal might well be

built on his plan, with the Gamboa viaduct, but always with the idea of converting it into a sea-level proposition on line of present sea-level plan, the lock canal to be abandoned when the other should be realized, and utilized thereafter as a drainage or diversion channel for the disposal of the flow of the Chagres and other minor streams on the right bank from Gamboa to Tiger Hill, but with existing knowledge of the topography and strata it is impossible to say what the cost would be, for every yard required to be removed in making the final sea-level canal would ultimately have to be taken out. I know the author of this suggestion, and have a high respect for him as an engineer."

That covers all that I have to say on that subject.

Senator MORGAN. If I understand your proposition or your conclusion about this matter, the viaduct that is proposed by Mr. Menocal could not be lowered below a 66-foot level.

General DAVIS. I think it is impracticable, Senator. You can think of it, that you would have to take the water down vertically about 60 feet below the present level of the surface before you could get it into the sluices.

Senator MORGAN. Leaving out the question of the regulation by valves, or whatever it is he has got in there, is it your judgment that a lock canal at a level of 60 feet can be connected with a sea-level canal below Gamboa, or in the vicinity of Gamboa, and carried across the Chagres River on a viaduct?

General DAVIS. No, sir; I do not think it can be on a viaduct. By the word "viaduct" you mean what in other parlance you might call a flume, made of concrete?

Senator MORGAN. Yes.

General DAVIS. In which the navigation would be conducted, while the flow of the river would pass under it. That is what we understand by "viaduct" in that sense.

Senator MORGAN. The regulation flow—that is, the overflow—

General DAVIS. The spilled water of the river above to pass under the viaduct.

Senator MORGAN. It would not fill the viaduct if it passed under it.

General DAVIS. It would pass underneath it entirely and have no connection with it. You see that in hundreds of cases of our own canals all over the country when the stream coming from the hills passes under the canal.

Senator MORGAN. I understand that; but, leaving the dam at Gamboa, as it is projected by the majority of the Board of Consulting Engineers, of the same height and thickness and width and everything of that sort; impounding the waters to the extent that you have already described in your deposition; is it practicable to locate two locks in the vicinity of Gamboa, between that and Matachin, having 30-foot lifts, so as to make a 60-foot transit across the Chagres River at that place through a viaduct, leaving the regulation works out entirely, and leaving them to be disposed of by some other process? Can two locks be put in there, in your judgment, to raise the level of the canal to 60 feet above sea level, convey the water across the Chagres River and on out to Miraflores? Is that practicable?

General DAVIS. I do not think it is, Senator.

Senator MORGAN. You think not?

General DAVIS. No; I do not think it is. The trouble with your viaduct is that it is not high enough; it is not high enough up.

Senator MORGAN. Far enough upstream?

General DAVIS. No, sir; not sufficiently elevated. It is not raised enough to serve the best purpose. In other words, you do not gain anything by using it. You would a great deal better come up with a lock canal along the valley of the Chagres, coming up with your locks, one or two below Gamboa and one at Obispo, and throw out the viaduct altogether, because it does not seem to me that the viaduct fulfills any useful purpose in that connection.

Senator MORGAN. Is such a plan as you have just suggested practicable, at a 60-foot level?

General DAVIS. No, sir; I should go higher.

Senator MORGAN. How much higher?

General DAVIS. To 90 feet, if you must make a lock canal; and I have a little something to say about that, if you wish to hear it.

Senator KITTREDGE. You mean, along the line of the Menocal plan?

General DAVIS. No, sir.

Senator KITTREDGE. That is some other feature?

General DAVIS. This is entirely separate and distinct.

The most readily transformable lock canal that I can think of would have about 90 feet for summit level, one lock of 30 feet, say at San Pablo—

Senator MORGAN. That is between Matachin and Gamboa, is it not?

General DAVIS (indicating on map). There is Bohio; there is San Pablo, and here is Gamboa; just about halfway. The other day I said it was about one-third of the way. It is about halfway.

Senator KITTREDGE. How many miles north of Gamboa is San Pablo?

General DAVIS. San Pablo is halfway between 24 and 25; the Chagres at Gamboa is halfway between 30 and 31.

Senator KITTREDGE. About 7 miles?

General DAVIS. It is 6 miles, about.

I was just saying that the most readily transformable lock canal that I can think of would have about 90 feet for summit level, one lock of 30 feet, say at San Pablo, another 2 or 3 miles above, and a third at Obispo on the Atlantic side, with the same number on the Pacific side, the most southerly one at Miraflores—all the locks practically on sea-level line.

Senator MORGAN. What would be the lift of those locks?

General DAVIS. Thirty feet each—90 feet.

Senator MORGAN. That would be 90 feet elevation?

General DAVIS. Yes, sir.

The cost of the locks and spillways would be in the neighborhood of 40 million dollars—

Senator MORGAN. The three locks?

General DAVIS. Six double locks.

Senator KITTREDGE. How does that cost compare with the cost of the locks at Gatun and at Miraflores—

General DAVIS. It is more or less the same. I have made it a little higher than their figures. They are all separate, you know.

Senator KITTREDGE. I understand.

General DAVIS. There are none of them associated together. They are not in steps.

Senator MORGAN. They are not in flights?

General DAVIS. No, sir; they are not in flights, like a staircase.

The cost of the locks and spillways would be in the neighborhood of 40 million dollars, or, if not in pairs, about 20 million, while the saving in excavation and tidal lock, covered by sea-level estimate, would probably reach 100 million, resulting in a net saving of about 60 million in the one case and 80 million in the other; but these figures are but a very rough approximation. It might possibly be finished in three or four years less time than the sea-level work, or in five years if single locks were used.

Single locks are not suggested as desirable; but as such a lock canal would be a provisional affair, to be replaced by the ideal type within a few years, single locks might be tolerated for those years, during which it may be expected the traffic will not be large.

I think that is a correct statement. The traffic in any canal or work of that kind will not jump to enormous proportions at once.

To transform such a waterway into one at sea level would cost 200 million, unless devices for excavation and removal should be greatly improved over present types and methods.

The only arguments in favor of the provisional arrangement are present decreased cost and a few years' saving in time. Ultimately the cost will be very greatly augmented.

Senator MORGAN. Your proposition, then, or your conclusion is that no lock canal can be constructed, we will say, between Gamboa and Miraflores to be supplied by the waters of the Chagres at a level lower than 90 feet?

General DAVIS. Oh, yes; it could be done, but it would not be as good a canal as this. It could be done. There is no doubt about your being able to do it, but the viaduct idea would be of no use to you.

Senator MORGAN. I understand. Leaving out that entirely, I am speaking of a lock canal 40 feet deep and of the width as proposed by the minority.

General DAVIS. That is what is contemplated.

Senator MORGAN. Could such a canal as that be constructed at a lower level than 90 feet to be supplied by the waters from the Gamboa Lake at a lower level than 90 feet above sea level?

General DAVIS. Oh, yes, sir. On this map that was covered up just now the widths are all exaggerated, so that it is not to a natural scale. By bringing a sea level to this point, which is just above Obispo, putting a lock there, which is shown on this map, and another lock there, which is shown on this same map, you then reach 60 feet above the sea and pass through the Culebra. At Paraiso you put in another lock here and drop down, and a mile below another lock here, at Pedro Miguel, and then you have a sea level Pacific marine section.

Senator MORGAN. That would be how many locks?

General DAVIS. Four at 30 feet.

Senator MORGAN. Four twin locks?

General DAVIS. Yes. But it would not save a great deal of excavation, because they are separated and the bottom of the canal will only be 20 feet above the level of the sea.

Senator MORGAN. Twenty feet at 90-foot elevation?

General DAVIS. No, sir. With a 60-foot elevation the bottom of the canal would only be 20 feet above the level of the sea.

Senator MORGAN. And how much with a 90-foot elevation?

General DAVIS. Thirty feet more—50 feet.

Senator MORGAN. Yes.

General DAVIS. I made a profile of this to see how it looked; but after I had the profile made I discovered the idea. You come up with the sea-level idea, say to here [indicating]; then you come up 30 feet; then you come up 30 feet more, like that; then you go through; then you drop down 30; then you drop 30 more, and all there is left to take out is a comparatively small amount. To save excavation and to save time as respects the Culebra, two of the locks should be a little outside of Gamboa—that is, north of Gamboa, probably at San Pablo and Matachin, for example, two of them, and a third one at Obispo. That brings you up to 90 feet. That will save more money.

Senator MORGAN. The main point in my mind, at least, about the whole matter, is whether or not a lock canal can be constructed between Gamboa and Miraflores to be fed by the waters from Lake Gamboa.

General DAVIS. Oh, there is not a doubt about that. There is three and a half times as much water for feeding that lock canal as the lock people have from Lake Gatun.

Senator MORGAN. But your present conclusion would be that it would require at least four locks?

General DAVIS. To make it the most economical type of canal—I mean to save the most money and the most time now, not looking to the future, but now, and to make it one that is transformable.

Senator MORGAN. Yes.

General DAVIS. I regard that as fundamental.

Senator MORGAN. Yes.

General DAVIS. The lock people, you know, do not regard the idea of transformability as of any importance. They reject that. They say, "A lock canal built now should be built for a long time to come." I take the other view as to that—that we should construct no canal whatever that is not readily adaptable to transformation.

Senator MORGAN. That the country will at last come to the proposition of a sea-level canal?

General DAVIS. Well, of course it is foolish to prophesy; but I think there is no doubt about that.

Senator MORGAN. We are all necessarily compelled to rely upon conjecture or calculation as to what is to occur hereafter. That is the trouble we are in to-day; we are trying to find out what is best to be done with reference to future conditions. So that if the Government should come to the conclusion that a sea-level canal from the Bay of Limon to the vicinity of Gamboa and a sea-level canal from the Bay of Panama to the vicinity of Miraflores should be fixed upon as an established, permanent proposition, you think that a lock canal is practicable between Gamboa and Miraflores, to be fed by the waters of Lake Gamboa?

General DAVIS. I have not a doubt of it; not a doubt of it.

Senator MORGAN. I am putting this proposition before the committee and before the Senate with a view to ascertaining whether there is any middle ground that can be taken by the Congress between the sea-level advocates and those who wish to make the lock canal as

a permanent establishment, and extend the flow of water by means of the dam at Gatun clear across to Miraflores.

General DAVIS. Yes, sir.

Senator MORGAN. There is evidently a contrariety of opinion as to which of the two propositions is the safe one and the better one, and I was trying to find whether there was a middle ground that could be taken, establishing a sea-level canal from the Bay of Limon to the vicinity of Gamboa and from the Bay of Panama to the vicinity of Miraflores, the interval to be supplied with a lock canal to be fed by the waters of Lake Gamboa, as we call it.

General DAVIS. Yes, sir.

Senator MORGAN. That was what I was trying to bring to the attention of the country.

General DAVIS. Yes, sir.

Senator MORGAN. I do not know that I have any occasion to press that question any further upon the attention of General Davis, unless some member of the committee wants to ask about it.

General DAVIS. There is just one word, Mr. Chairman, that I might say as bearing upon remarks made formerly (that is, Friday) in this committee respecting the idea of waiting to see the result of this excavation as regards the necessity for a tidal lock—that was one of the points—so as to ascertain what rate of progress might be attained in the excavation, the idea being that the work as it progressed might furnish examples and demonstration, and that the final realization of the sea-level plan would thus be made manifest.

That is all right, but you can not wait very long before you determine definitely the matter of type. You can not wait very long, for it is going to take a good while to build those locks. You can not afford to stand still on the lock proposition, waiting to see how well you get on in excavation. In other words, you must begin at once to make those lock pits. It is going to require the removal of an enormous amount of earth to get a pit in which to put the locks. It is going to take two or three years to make the lock pits.

Senator KITTREDGE. You mean the excavation?

General DAVIS. Yes; the excavation for the locks is going to take two or three years. The minority estimate it will take four years to make the Gatun locks, or three and a half—I have forgotten now whether it is three and a half or four. So, if you are looking ahead to a date when you can see your canal completed, you can not afford to wait very long before you begin to build your locks. It will take a good many months and years to do that. Therefore that phase of the matter should not be overlooked.

Senator MORGAN. I suppose you have some conception (perhaps not a calculation) of how long you would have to wait before you could determine whether you would make a sea-level cut between Gamboa and Miraflores, or wherever you would interpose a lock canal?

General DAVIS. Yes; of course I could not say about that. I only know that the engineers who are going to build that canal ought to know as soon as possible whether they are going to build locks or not. They ought to know that. As to the idea that is expressed in this paper about a provisional canal, I myself think that for twenty years after the canal is opened a single lock will serve all or nearly all the purposes. A single lock served at the Soo, you know, from 1855 to 1886, I think it was, or 1882. I have forgotten the year now.

Senator MORGAN. Until the commerce got so great—

General DAVIS. Until the commerce got so great as to force them to build larger ones. Now, if you build a single lock it will probably pass all the shipping that will present itself there; certainly it will pass all that is likely to come in the next twenty years. And even if it was attended with some difficulty or some delay you would be so much better off even with that sort of a plan than you are without any that you would be willing to tolerate some inconvenience and then look to the ultimate, which is the taking away of these provisional locks and going down to sea level. I am not a lock man, as you know, and I am only speaking of this as something that is a sort of a forced compromise.

Senator MORGAN. The situation is such and the contrariety of opinion—at least as I believe it to be—at this board is so great that it is worth while to look for some plan that will cause the opposing and antagonistic views to meet. I think it worth while, so I have been trying to look into the question to see what the possibilities are in regard to the construction of the canal.

General DAVIS. I should not think you ought to take my offhand opinion on this subject as settling any question of cost or expense or time.

Senator MORGAN. Oh, no; I am not trying to hold you to it as a settled and fixed opinion at all. While it is not conjectural, it is the statement of opinion of one who knows all about the local situation, which, of course, the committee can not know personally.

General DAVIS. In the course of ten days, I suppose, a computation could be made so as to give you figures as exact as those the majority and the minority have given you.

Senator MORGAN. Yes.

We have been speaking in the course of this general examination of the necessity for a change in the roadbed of the railroad. I have not as yet been informed as to what change is proposed to be made or the necessity for it. The railroad as it is now built runs up to Barbacoas and there it crosses the Chagres River?

General DAVIS. Yes, sir.

Senator MORGAN. From the right bank of the Chagres to the left bank?

General DAVIS. That is right.

Senator MORGAN. How far does that railroad pursue what we might call the valley of the Chagres before it leaves and goes—

General DAVIS. It crosses at mile 24, and comes on here. Now, to what point, Senator? You say how far is it from where it crosses to what point?

Senator MORGAN. To Miraflores.

General DAVIS. Miraflores is at mile 41—17 miles.

Senator MORGAN. The length of the railroad from the time it crosses the Chagres at Barbacoas until it reaches Miraflores is—

General DAVIS. Is 20 miles.

Senator MORGAN. Is 20 miles; and that is to the westward of the canal line?

General DAVIS. It is at the westward of the canal line, except that at mile 39 the present railroad track recrosses the line of the canal, and from that continues on the northern side of the canal line all the way to the city of Panama.

Senator MORGAN. So that the railroad as at present constructed would cross the canal line at two places—first at Barabacoas and afterwards go back?

General DAVIS. Yes, sir; and afterwards go back on to the same side again just here between Pedro Miguel and Paraiso.

Senator MORGAN. Now, please indicate what change is to be made in the location of the line of the railroad in the heights there between Gamboa and Miraflores.

General DAVIS. I think it is agreed by all engineers who have studied the matter, and I think they all admit this is a fact, that the railroad may stay just where it is until you are ready to open the canal for traffic. Of course you will have a high bridge across here at Pedro Miguel, and you will have a suitable crossing here at Barabacoas, perhaps with a draw in it, so that the dredges can go backward and forward. But I think that we all agree that the railroad track may stay where it is until your canal is ready for use as a canal.

Senator MORGAN. Having draws to allow the passage of the dredges?

General DAVIS. Yes; during construction.

Senator KITTREDGE. That is on the sea-level plan, General?

General DAVIS. Yes; on the sea-level plan, and I do not know but I should say on the lock plan, except that on the lock plan, so far as Lake Gatun is concerned, when that lake is filled (which would not be until just before the canal was opened) the railroad must then be carried around the margin of the lake and must keep away from it. It is the proposition of the lock-canal advocates to divert the railroad from Gatun and keep on nearly uniform ground, or, rather, ground above the proposed level of the Gatun Lake, and so swing around in here, crossing the Chagres just below Gamboa, where the Frenchmen built the railroad bridge which some of you gentlemen have seen.

Senator MORGAN. That will be on a bridge?

General DAVIS. That will cross on an iron or steel bridge that is there now, and then swing along on these hills, winding around, avoiding grades, and so on down until you come to Pedro Miguel; and then it will run where it was first intended to, and where it has been all the time, to Panama.

Senator KITTREDGE. That contemplates, then——

General DAVIS. A long diversion.

Senator KITTREDGE. Practically a diversion for practically the entire length of the line?

General DAVIS. Yes.

Senator KITTREDGE. That is, from Gatun to Miraflores?

General DAVIS. Yes; or from Gatun to Pedro Miguel. It contemplates a diversion all that distance.

Senator KITTREDGE. And the abandonment of the villages and tracks between those points?

General DAVIS. Oh, yes; certainly.

Senator MORGAN. It is practically the construction of a new road?

General DAVIS. Yes.

Senator MORGAN. From Gatun to Miraflores?

General DAVIS. Yes; that is what it is.

Senator MORGAN. And on the opposite side of the canal from where it is located at present?

General DAVIS. Yes, in part.

Now, as a sea-level proposition, the railroad question seems to be this: During construction the railroad is going to be of immense importance, of very great importance. After the canal is finished the railroad is simply going to be a convenience and of minor importance, but still it will have to be kept up. Probably it will be a trolley road. It will not be a freight road except for small, local freight; but it will be a convenience to the inhabitants and to the canal officials, and enable them to get quickly from one side to the other of the Isthmus.

When the sea-level canal is made, it has always been contemplated that from Barbacoas the sea-level canal would be laid right on the levee alongside of the canal, close to it, right along what you might call (speaking of canals as they exist in this eastern country) the "towpath."

Senator MORGAN. And through from ocean to ocean?

General DAVIS. Yes. I would not move it down here [indicating]; but from Barbacoas on it would simply be run right along on the edge of the navigated sea-level canal until you got into Culebra, and then it would go right through on that bottom terrace.

Senator MORGAN. Without crossing the canal?

General DAVIS. No, sir; you could not cross it anywhere at all. It would follow right through on the bottom terrace of the Culebra excavation.

Senator MORGAN. That would involve also the reconstruction of the railroad?

General DAVIS. It would involve the laying of the track on a grade already prepared.

Senator MORGAN. That means reconstruction?

General DAVIS. Yes, sir; it would be a new track—the old rails simply shifted over.

Senator HOPKINS. In both instances, then, it would be practically a reconstruction of the road, would it not?

General DAVIS. In one case it would involve a very large amount of grading and in the other the grading would be saved; that is the difference; and the miles would be less on the sea-level idea than on the lock idea.

Senator MORGAN. But in either case it is contemplated that when the canal is finished the railroad will become worthless except as a convenience for the canal?

General DAVIS. Yes—as a "tender," you might say.

Senator MORGAN. And it would cease to be a channel of commercial intercommunication between the oceans?

General DAVIS. Quite so; quite so. It would be similar to the railroad that now traverses the whole Suez Canal from end to end; it has a meter gauge.

Senator MORGAN. Has this subject, within your knowledge, ever been brought to the attention of the Government of Panama—the fact that on the completion of the canal they would lose all advantage of the railroad as a freight transporter, as a business line of intercommunication between Panama and Colon? Has that ever been discussed?

General DAVIS. It would or it would not be lost, depending upon the policy of the United States. If the United States ran trains there, they could charge fares to the people who used it, and they

could charge for carrying packages, small amounts of freight that it might be wished to ship from one merchant to another. It would be very small.

Senator MORGAN. But the canal would supplement the railroad?

General DAVIS. Oh, yes.

Senator MORGAN. For the commercial convenience of Colon and Panama?

General DAVIS. Oh, yes; the canal would be open for any kind of vessels that wished to navigate it, small or large. The Suez Canal is. Even sailboats are now going through Suez, you know—little yachts, and naphtha launches, and all that sort of thing.

Senator MORGAN. My recollection of the Hay-Varilla treaty is that that canal is to be open for the use of the people of Panama or the Government of Panama without any charge for its use.

General DAVIS. I have not its verbiage exactly in my mind, but I think that provision relates to the present custom of giving passes to officials of the Panama Government and employees of the Panama Government.

Senator MORGAN. I doubt not that it did relate to that in the minds of the negotiators of that treaty; but I called attention at the time to the fact that the language was so broad that it put us under the obligation, in my judgment (at least that is my present opinion), of transporting all vessels of every description that might be called national vessels of Panama through the canal, backward and forward, without any charges for lockage or anything else.

General DAVIS. I think that would be the case if they were national vessels and had no commercial character. But if they were engaged in commerce, I think not.

Senator MORGAN. That clears up the situation so far as the railroad matter is concerned, in my mind, at least. I had it confused.

General DAVIS. You spoke about the necessity for double tracking, did you not—that you could not understand the necessity for double tracking?

Senator MORGAN. We have spoken of that heretofore; but the double tracking that is to be put on the railroad is evidently for temporary use.

General DAVIS. Yes; that is it.

Senator MORGAN. For purposes of transporting and hauling for the canal.

General DAVIS. Yes.

Senator MORGAN. And accommodating the commerce that now exists.

General DAVIS. Yes; that is right.

Senator MORGAN. So that in the contemplation of both plans, the sea-level plan and the lake or lock plan, the railroad, at the completion of the canal, is expected to cease to be an important factor in commerce between the oceans?

General DAVIS. I think so; I have no doubt of that. It will be maintained as a trolley line.

Senator MORGAN. So that that sacrifice, if we may call it such, is to be added to the cost of either system of canalization, either by the lock system or the sea-level system?

General DAVIS. Yes, sir.

Senator MORGAN. I do not know of any other general topic on which I wish to ask the General any particular questions. There may be some explanations that he wants to give of his deposition as to matters that may have escaped our attention and his at the time. If so, General, you will please proceed to state them.

General DAVIS. I have made a few notes of matters that have occurred to me in the reading of the testimony of others as bearing upon administration, not as affecting the type of the canal at all, but administration. Some of them have been covered in the examination already had, and others have not, and I do not know that there is any very great importance in any of these that I have made a note of. I will refer to a few.

One subject that was discussed in this committee, and in regard to which several questions were asked of Governor Magoon, was the matter of allotments of pay by employees to their families in the United States.

Senator MORGAN. Yes.

General DAVIS. I have had some personal experience in regard to that matter in the Philippines. Until two or three years ago (I have forgotten the date now) it was customary to allow soldiers—I do not think officers were included—to allot a certain percentage of their pay to their families in the United States. That was continued during my time in the Philippines, although I think it has since been discontinued. It involves considerable clerical and administrative work and some difficulties which do not appear on the surface.

A man who is employed by the United States at a stated salary may be expected to have a credit at the end of every month to the amount of his pay, and that is the presumption when an arrangement is made for an allotment. But a man in the Philippines, 7,000 or 9,000 miles away, deserts or dies or is fined by a court-martial in respect to his pay, so that he has no pay coming to him; then the allotment immediately falls. But as the distance is so great, it is necessary to inform the accounting officers in Washington by cable every time a man's pay status changes in the way of reduction of pay—do you catch the idea?—and that cabling bill in the Philippines in respect to soldiers' allotments was a very large one.

It cost the Government a great deal of money to keep the Paymaster in Washington informed in regard to the many, many, many cases of men whose pay status was entirely changed. The orders of the War Department were such that it was made obligatory upon the commanding general and those who were under his orders to inform the War Department in every case; and if there was any omission, and the information was not sent that the man had died or deserted or been fined by a court, the commanding general or the officer at fault had to pay that money. That has been done time and again.

So that if you establish a system of allotments for the employees at Panama, you must also have a system of checks or reports that will reach Washington before the time comes for the Washington disbursing officer to send out the check to the man's family. And that comes to the question of the cable, which I think is an important matter.

At present there is cable communication with the Isthmus by way of Mexico and Central America, frequently called the "Galveston

Line." The name of it is the Central and South American Cable Company. There also used to be communication with Panama on the Caribbean side by the line of a British company, called the West India and Panama Direct Line; but that went down some months ago, and it has not been brought up since.

Senator MORGAN. What made it go down?

General DAVIS. Oh, I do not know. They are going down all the time, and it did not pay. The whole matter was that it did not pay, because the Central and South American cable had made a very low rate (that is, 25 cents a word) for Government messages—not for private messages, but for Government messages. They made a rate of 25 cents a word, so we have been using that cable since; and there was not enough business so that the British line cared to go to the trouble of raising that cable and splicing it. It went down somewhere south of Jamaica; I have forgotten where.

A proposition has recently been made, and is now pending in Congress, to build a Government line for military and naval purposes, connecting Key West or some point on the coast with Colon. I think that is a very worthy suggestion, a very excellent idea; and it will permit free and constant communication. It is a military instrument of great importance, and in time of war would be of the utmost importance. It will also enable the employees of the United States on the Isthmus to communicate with their families speedily without paying this enormous charge. That is, I think the Government ought to permit its own employees to use such a cable at a nominal rate; and now it is a very expensive one.

That is all I care to say on that subject.

Senator MORGAN. Was not this cable between Jamaica and the coast down there broken at the time of this recent earthquake?

General DAVIS. Oh, no, no; it was a year ago—a year ago.

Senator TALIAFERRO. General, I will state that a favorable report has been authorized on a bill to construct a cable from Key West by way of Guantanamo and Porto Rico, and presumably on to the Isthmus.

General DAVIS. It is a very excellent idea.

Senator TALIAFERRO. While you are on that point of allotments, is there any reason why an employee should not be paid in a Treasury draft on the Isthmus?

General DAVIS. I do not know of any reason in the world.

Senator TALIAFERRO. Do you not think it ought to be done?

General DAVIS. I think so. I said so here the other day, I think.

Senator TALIAFERRO. I understood you to say so.

General DAVIS. Oh, I think so. I think that if a man has saved up some money down there, even though he was paid in currency, and wants to remit that money home, he ought to be able to go to the paymaster and get a check without paying any premium for it.

Senator TALIAFERRO. I agree with you.

General DAVIS. It seems to me it is one of the simplest kinds of accommodation that the Government ought to give its employees.

Senator MORGAN. There is another matter suggested to my mind by your statement there, and that is the apparent necessity of having transactions in regard to the payment of laborers and employees of every kind finally closed at the Isthmus without their being referred here.

General DAVIS. That is the way it is done now. They do not use any allotment system now.

Senator MORGAN. They do not?

General DAVIS. Oh, no; but some gentleman was urging that there ought to be a system of allotments. I am only speaking about allotments to show that there are some difficulties attending their operation.

Senator MORGAN. But the payments now can be made to all classes of employees, and their accounts all settled up at the time that the payment is due without a previous audit?

General DAVIS. Oh, yes; certainly. They are now settled promptly. There is no trouble about that.

Senator TALIAFERRO. General Morgan, the point we were trying to get around was the charge made by the banks on the Isthmus as exchange where an employee wanted to remit part of his money home.

Senator MORGAN. I understand that.

Senator TALIAFERRO. That charge is excessive.

Senator MORGAN. I think that is a very burdensome exaction upon the employee.

General DAVIS. I have been in the Army all my life, and I have been in a good many parts of the world, and there never has been a time when I or anyone under me, or any private soldier who had pay coming to him, could not go to the paymaster and get a check on New York or somewhere to send his money home. There never was a time when that could not be done. We could always do it, and I think the employees on the Isthmus ought to have the same privilege.

Senator TALIAFERRO. The greater the conveniences you afford them the better satisfied they will be?

General DAVIS. Why, certainly; and it does not cost anything to do that. It makes necessary the writing of a few checks; that is all it does.

The feeding of laborers has been referred to here as something that ought to be done by contract. I do not agree with that. I do not believe you will ever get a system of feeding laborers on the Isthmus in any messing plan that will be satisfactory. They are the most cantankerous people in the world. There is no such thing as satisfying the notions of those people about their food. If they are charged an upset price for it, they are never satisfied with it. The only way, it seem to me, is to pay them their wages and let them feed themselves. I am talking now about the common labor—the negro labor.

Senator MORGAN. Then you would have to have supplies of provisions there?

General DAVIS. Oh, I would have stores, where they could go and buy their provisions; yes.

Senator MORGAN. Then the Panamans would dispute your right to do that, would they not?

General DAVIS. They would not if—

Senator MORGAN. They have done it heretofore.

General DAVIS. But they have kept the commissaries going.

Senator MORGAN. General, was this reservoir at Colon built during your administration there?

General DAVIS. You refer to a recent press report saying something about a failure of water supply?

Senator MORGAN. Yes.

General DAVIS. I am not quite sure that I have all the facts; but my impression is this:

The Panama Railroad has had a water supply for Colon for the last fifty years. It is obtained from the natural drainage of some hills that go by the name of the Monkey Hills. It is about 2 or 2½ miles from the city of Colon. A lake was made there, impounding enough water to furnish the railroad with its requirements, the vessels in the harbor, and the native inhabitants. The increase of population and the consumption of water in Colon since the taking over of the work by the United States has brought about a condition of affairs that indicates inadequacy of water. The engineers are building a new supply (they commenced it before I left), impounding water in a stream 2 or 3 miles farther out. I think about 200 or 300 million gallons are proposed to be impounded, a pump erected, a standpipe also, and a distribution system laid down for Cristobal and for Colon.

I do not think that work has yet been completed; but a provisional supply was procured, as I learned when I was there in September of last year; a temporary dam was built on this same stream, and a provisional supply obtained, which supplemented the Panama Railroad supply from Monkey Hill. I read in the newspapers that this supply has failed; and somebody has sent a sensational dispatch up here to the effect that there is a water famine there, and great trouble and tribulation.

Last year, when I was governor, at the dry season (which is now; this is the dry season there), we had the very same condition of things; and they have had it every year. They have had it there every year for years and years; and the way the situation is met is to economize as well as they can with the water, and then for the Panama Railroad to run water tanks out to Tavernilla and bring in three, four, five, or six carloads of water every day, for which they have cars specially built.

Senator MORGAN. How far out is that?

General DAVIS. Oh, about 20 miles or 25 miles, where they water their engines.

Senator MORGAN. It is above Bohio?

General DAVIS. Oh, yes; it is above Bohio, and they bring in the water. They did last year, and I suppose they are doing it now; and that to which you allude, I think, is nothing but sensation. I do not think that it amounts to anything of any serious importance.

Senator MORGAN. And if there has been a failure of the reservoir there, it is this temporary structure?

General DAVIS. This temporary structure that has gone dry, probably, or nearly so.

Senator MORGAN. Has that reservoir stood during the fifty years that the French had the supply for their railroad?

General DAVIS. Oh, yes. That Monkey Hill reservoir has been in use there all the time, and they have been making use of these tank cars to bring water in from Tavernilla whenever they happened to run short. They run the cars out and fill them up, and then run them alongside of the ship and put a hose into the ship and fill the ship's tank—ships that are going on foreign voyages.

Senator MORGAN. Is it good water?

General DAVIS. Oh, yes; it is very good water, and it is like the water we are using now in Panama. It comes from the head of the Rio Grande.

Senator MORGAN. As a rule, the water in Panama is good when you get it coming out of the hills?

General DAVIS. Oh, yes; it is all right. It contains a little bit of sediment and some little vegetable matter, but nothing that has ever done any harm. Typhoids and dysenteries there are almost unknown. There have been one or two cases of typhoid fever in the Panaman hospitals in a year; that is all. There are very few cases.

The matter of the Zone delimitation, which is covered by the report which the committee has ordered to be printed, will require for the elucidation of that idea the printing of these three maps to which I have alluded, if you care to have it done. I think I ought to describe to you what that Zone delimitation means, so far as Colon is concerned, because it is shown by this map. This [indicating] is Limon Bay; this is Manzanillo Island; this is the line that the Frenchmen proposed for their canal.

Senator MORGAN. For the sea-level canal?

General DAVIS. Yes; or any canal. That is the French plan of canal. The American plans—that is to say, the plans of the Board of Consulting Engineers, the majority and the minority—come in here, like that [indicating].

The CHAIRMAN. It is marked up there, General?

General DAVIS. Yes; it is shown here also. It joins in here at Mindi.

Senator MORGAN. Have you any doubt that under any plan of canal we may adopt, it ought to enter the Bay of Limon, instead of going by Colon?

General DAVIS. Oh, I think this idea here is an absurdity. The French idea of entering this canal is an absurdity. You can get an idea of the curve by following that bend, the way a ship has got to proceed. That curve there has a radius of—I have forgotten what it is—about 1,600 feet; that is, that ship has to make two turns, one here and one there, before she can straighten out and go into the canal. It is utterly out of the question. I think everyone agrees on that.

In regard to this matter of Zone delimitation, it is specified, as you will find in that agreement, of which you have a copy, that the line of delimitation between the Republic of Panama and the United States for the Canal Zone shall follow this general plan:

The Hay-Bunau-Varilla treaty specifies that the city of Colon shall remain in the jurisdiction of Panama and its harbor shall remain in the jurisdiction of Panama. Those conditions are stated. Now, therefore, I negotiated with the Government to find the mode by which we could come to an understanding.

The city of Colon consists of this sort of a strip of houses here. That is all that really is built up into a city. This is a mangrove swamp covered with water at high tide and nearly bare at low tide, the tide being only about 2 feet. It was provided in the agreement that I made with the Government that the line of demarcation should begin at this point—Cristobal Point—that from that point a line should be projected across Limon Bay to its west shore in a due westerly direction—this point being fixed and determined; a monument stands there to Cristobal Colombo. That, then, is a due west

line, and everything lying inside of this line belongs to the Zone. Everything outside of it pertains to the harbor of Colon, except as I will state a little later on.

From that point the line of delimitation follows the shore line at low water until it arrives at the intersection of a certain street in the city which is described in the agreement. It follows the center line of that street for that short distance [indicating] and crosses the Panama Railroad track. It then follows on a line parallel with the Panama Railroad track—

Senator KITTREDGE. On which side of the track?

General DAVIS. On the east side of the track—the city side; the Manzanillo Island side, as I remember—always at 150 meters from the center line of that track, until it reaches the shore of the Fox River here; then following around the shore of the Manzanillo Island back here to the light-house.

Now, what is inclosed is in the city of Colon and not within the jurisdiction of the United States. What is on the south side of that line, including all these railroad tracks and this Cristobal Point and a considerable corner of the city itself, where all the shops and the new wharves are here, is in the Zone.

It also provided in the same agreement that a zone 660 meters wide, from the open sea, passing through this harbor on any line that the canal may ultimately take, even the part that passes through the harbor of Colon, shall be under the exclusive jurisdiction of the United States, so that under this agreement a vessel can enter the Zone and always be entirely within the United States jurisdiction, even though it traverses the harbor of Panama.

I thought that was a very important matter to secure perpetual control over ships entering the canal and not have any dispute about right in regard to that matter, so that is covered by that agreement. So wherever the entrance to the canal is, a zone 2,000 feet wide through the harbor of Colon, Republic of Panama, will be under United States jurisdiction.

The map on the Panama side contains a description of the Zone lines also; but it is rolled up now, and if it is printed you can always consult it.

There was a subject mentioned in the statement of Governor Magoon about a dispute that occurred in the city of Panama, in which the Panama police intervened, and I received a letter from the chairman of the Commission saying that you would probably wish to ask me some questions in regard to that. It was a sort of a riot that occurred in the city of Panama during my time there. Was that the case, Mr. Chairman?

The CHAIRMAN. Yes, sir.

General DAVIS. As bearing upon that, I have here a copy of a letter that I wrote to Mr. Wallace on the 3d of May, 1905, in which there is a description of the incident referred to, and all of the facts concerning it are there stated. I do not know that it is a subject that you care particularly about.

Senator HOPKINS. Let it become a part of his testimony.

The CHAIRMAN. It might become a part of the record unless the General wishes it read.

General DAVIS. I do not care to say anything about it.

(The paper referred to will be found printed at the end of to-day's proceedings.)

General DAVIS. There is one other small matter:

When I went to the Isthmus, under the order of the President of May, 1904, one of the duties imposed upon me was to announce in a public manner the purposes for which the government of the Zone was established. I arrived on the 17th day of May and paid my respects to the President of the Republic, and on the 19th of May I made a publication to the inhabitants of the Canal Zone, which was in print; and this is the document in my hand. It is the first public announcement of the purposes for which the government of the Zone was being established by the United States.

Senator KITTREDGE. I think that might as well be printed in connection with the statement.

(The paper above referred to will also be found at the end of to-day's proceedings.)

General DAVIS. There is one other small matter. It is as to a description of the functions of the officials who are transacting the business of the Government on the Zone in an engineering way, or in any other way that involves the use of property, and as respects the designation of that property. It is the custom now to speak of it as the property of the Isthmian Canal Commission.

The locomotives, the dredges, the steam shovels, and the cars are all marked "I. C. C.," and it is in the common language of the day that that is the property of the Isthmian Canal Commission. It is a custom that grew up from the very beginning. What its origin was I have no idea of, only that it has been confirmed by constant usage.

It seems to me that such a description of that property is inaccurate. If there is any mark on a car or a locomotive or a steam shovel it seems to me it ought to be marked "U. S.," as the property of the United States.

It is not a matter of great importance, but it seemed to me to be quite anomalous, inasmuch as the Commission does not own anything, has no ownership whatever, and as the brand on it indicates ownership, it struck me as more appropriate to speak of a contract being made between the United States as party of the first part and John Smith as party of the second part rather than as between the Isthmian Canal Commission as party of the first part and John Smith as party of the second part. It is only a very small matter.

I have nothing else that I care to refer to.

Senator MORGAN. There was a charter party for the two ships that were bought by the Isthmian Canal Commission between the Canal Commission, representing the United States, and the Panama Railroad Company?

General DAVIS. I have understood so.

Senator MORGAN. Yes. I had copies of that charter party published the other day. That is equivalent to a contract by the United States with itself?

General DAVIS. It seems so to me.

Senator MORGAN. If it should get into a court, it would be, of course, impossible to enforce it. The transactions that have been conducted by the railroad company there, or the railroad directors and their superintendent or general manager, or whatever it is, have

been nominally between the railroad company and the Isthmian Canal Commission. Now, in the direction of the operations of that railroad—in the fixing of freight rates, in the transportation of goods across the Isthmus, and in the connections that are made with the commercial ships that come into either of the bays—is it a fact that the railroad directors and managers have the exclusive control and charge of those matters, or are they regulated and controlled by the Isthmian Canal Commission?

General DAVIS. The board of directors of the Panama Railroad, as I understand, are all nominees of the stockholders—all represented by one individual—the Secretary of War. The board of directors of that railroad therefore must, as a matter of necessity, carry out the policy of its stockholders. In other words, the Secretary of War has the right and the authority to dictate to those directors what policy shall be pursued in the management of the railroad, since every share of stock, as I understand, stands in his name.

It so happens that all the members of the Isthmian Canal Commission are members of that board. They have two duties. One duty is to perform what is assigned to them as members of the Isthmian Canal Commission. The other is to do their duty as directors of the Panama Railroad. I think all the members of the Commission are members of the board of directors—at least I have understood so.

Mr. Shonts, who is the chairman of the Isthmian Canal Commission, is also the president of the board of directors of the Panama Railroad. An executive committee has been formed among those directors. I think it has three members, but I am not quite sure about it; and that executive committee has delegated to it by the board certain functions which enable it (the committee) to dispose rapidly of any questions that may arise.

Senator MORGAN. Who comprise that executive committee?

General DAVIS. I could not tell you offhand, for it never has been of any concern to me. I only know that Mr. Shonts is the chairman of the board of directors and is also chairman of the executive committee, and I think Mr. Drake, the vice-president of the Panama Railroad Company, and who has been for many years, is also a member of that executive committee. Who the other members are I do not know. I presume Mr. Cromwell is a member, although that I do not know of any personal knowledge. But there is an executive committee consisting of either three or five members, I am not sure which, and they meet weekly. I think, as a matter of rule, and may meet oftener. The board of directors only meets monthly; once a month.

Senator MORGAN. This board of directors and this executive committee of the railroad company transact and control all of the business of the railroad company, unless the Secretary of War or the Isthmian Canal Commission undertake to give special directions about some matter?

General DAVIS. I suppose that in the transaction of the business of the board it is like all other boards—that somebody makes a motion, and then that motion is seconded, and it is discussed and voted upon.

Senator MORGAN. The point I was getting at is more particularly this—I perhaps did not indicate it clearly enough: The Isthmian

Canal Commission, as a commission, does not undertake to direct the board of directors of the railroad company?

General DAVIS. No, sir; not as it now exists. Under the orders of the President, which were made in May, 1904—that was a direction that he then gave—that all the members of the Isthmian Canal Commission should be elected on the board of directors of the Panama Railroad, and that the policy of the railroad should conform to the policy of the United States. But as I understand, under the modified orders of the President, issued since I left the Commission or about the time I left it, about which I have no personal knowledge, that has been changed. That is, that method of procedure has been changed, although I am not quite sure about that; I do not want to assert that as a fact.

Senator MORGAN. What method, do you understand, has been substituted for it?

General DAVIS. Simply that the Secretary of War, as the only stockholder—that is, the United States as the only stockholder, the Secretary of War as its trustee—indicates to the board of directors of the Panama Railroad the policy that he wishes pursued.

Senator MORGAN. And that takes it out of the reach of the Commission?

General DAVIS. Not out of the reach of the Commission, because every member of the Commission is on the board.

Senator MORGAN. I understand that; but it takes it out of the reach of the Commission as a commission?

General DAVIS. I should think so; yes, sir; I should think so.

Senator MORGAN. And transfers that power of general control and direction to the Secretary of War?

General DAVIS. I do not know that it transfers it; it inherently lies in him.

Senator MORGAN. It leaves it in him, then?

General DAVIS. Yes, sir.

Senator HOPKINS. That is simply a conclusion of yours, is it not, General? All you know about it is that the members of the Commission are directors?

General DAVIS. I only know that by public report.

Senator HOPKINS. Yes.

General DAVIS. I do not know that officially.

Senator HOPKINS. And as to whether they are subservient entirely to the Secretary on every question that comes up on the road, or whether they have independent opinions is a matter you do not know of?

General DAVIS. No, sir. I presume that he trusts those men as wise men, and he wants their judgment, and relies upon them to act wisely.

Senator MORGAN. But you do know that as a commission, as an Isthmian Canal Commission, a body called the Commission does not undertake by any resolution or otherwise to control the board of directors of the Panama Railroad.

General DAVIS. I know that by common report. I have no other knowledge.

Senator MORGAN. You were familiar with the records while you stayed there?

General DAVIS. When I was on the Isthmus I never attended a board meeting of the Panama Railroad directorate.

Senator MORGAN. Although you were one of the directors?

General DAVIS. Although I was one of the directors; but their meetings were in New York, and I was in the Tropics.

Senator MORGAN. But while you were governor there and a member of the Commission, was any order passed by the Commission to the board of directors of the railroad company that they should do any particular thing, or do thus and so?

General DAVIS. No, no; no, sir.

Senator MORGAN. That is, no control was attempted to be exercised by the Isthmian Canal Commission over the board of directors of the Panama Railroad?

General DAVIS. No, sir; I think not.

Senator MORGAN. Or over its superintendent or general manager?

General DAVIS. No, sir. Mr. Wallace was elected or appointed superintendent of the Panama Railroad during my time. He did not wish to serve in that capacity, but—

Senator MORGAN. But the two establishments, in all their transactions and in their accounting and everything of that sort, are entirely separate?

General DAVIS. Entirely separate and distinct; yes, sir; although now, I think, their accounts are audited by the auditor of the Isthmian Canal Commission.

Senator MORGAN. They come under the Canal Commission?

General DAVIS. Yes, sir.

Senator MORGAN. But there is a separate audit for their accounts?

General DAVIS. I think they have an auditor of their own in New York; but of that I am not sure.

Senator MORGAN. Yes; but the accounts in their origin and in their payment of demands and liabilities and whatever takes place, including purchases for the railroad, are all conducted through that corporation?

General DAVIS. I am afraid you are getting beyond my knowledge. I have an impression—I have heard it said—that the purchasing agent of the Isthmian Canal Commission is also purchasing agent for the Panama Railroad. I think one of your witnesses here stated that. I think I have read it here.

Senator MORGAN. I have a different impression. I thought they had a purchasing agent for the Panama Railroad there who sometimes acted for the Commission.

General DAVIS. I think I have read it that way, although I do not know; I am not quite sure.

Senator MORGAN. The coal supply, for instance, that goes into the Isthmus over the railroad and is conveyed by its steamers, is a separate account between the Canal Commission and the railroad company, the railroad company furnishing the coal at a certain price to the Commission?

General DAVIS. Yes, sir.

Senator MORGAN. That applies to pretty much all the coal that has even been used there?

General DAVIS. I think to all, except one cargo, or something like that.

Senator MORGAN. That only illustrates the separation and independence of action of those two bodies.

General DAVIS. Yes. I think the corporation is, in a legal sense, or is intended to be, entirely separate from the Commission.

Senator MORGAN. I believe that this is the day, is it not, for the election of a new board of directors?

General DAVIS. I only know that it is early in April. I am not quite certain about that.

Senator MORGAN. I think it takes place to-day in New York.

General DAVIS. I know it is early in April.

Senator MORGAN. I think Mr. Taft has gone there now for the purpose of electing a new board of directors of the Panama Railroad Company. Of course you have no idea who will be chosen or who are the candidates?

General DAVIS. No; I have no idea at all. I presume the old board will be reelected, although I have no knowledge about that.

Senator MORGAN. I have very grave apprehensions that they will not be, if I may state it in that way.

You mentioned, General, the opinion that it would be preferable for certain reasons (and very important reasons, too, I acknowledge), if we entered upon the contract system of building this canal, to put the entire canal under the charge of one company or establishment or contractor.

General DAVIS. I thought so, sir. I am certain that if this canal was to be built by private capital that is the course they would pursue.

Senator MORGAN. Yes; and that a subdivision of the contracts might lead to conflict?

General DAVIS. I think it would; I think it would.

Senator MORGAN. And particularly in the use of the railroad?

General DAVIS. Yes, sir; I think that is a thing that is vital to it—like the Siamese twins, you can not cut them apart.

Senator MORGAN. It would seem to be a very difficult proposition to leave the railroad in the hands of one company or contractor amongst many.

General DAVIS. Oh, yes; it would be very difficult. I do not think that the idea of turning it over to a contractor would result in any friction or difficulty.

Senator MORGAN. To one contractor?

General DAVIS. To one contractor.

Senator MORGAN. But it would be very likely to do it in case several contractors were interested in the transportation to be furnished by the road?

General DAVIS. Yes.

Senator MORGAN. That would be very likely to lead to conflict?

General DAVIS. Yes; I think it would, unless the control of it lay in the hands of the chief of the whole contract business, the one that had the responsibility of the building of the whole canal. Of course that would be a corporation. It would not be any one man; it would be a syndicate of capitalists.

Senator MORGAN. The question is an important one in connection with the matter of laying out the contract if we conclude to farm out the work, and I was interested in trying to understand about it as well as I could. It would be possible for the Government to retain

the separate and exclusive control of all transportation by the railroad and all of its branches and spurs, and to keep an account with the different contractors of the use that they might make of the road in the transportation of material, for instance, and supplies, or whatever else they had to transport over it. That would be possible?

General DAVIS. Oh, of course it is possible, yes; but the fewer employees the Government has on its pay roll on the Isthmus the better, I think.

Senator MORGAN. In the case of doing the work by contract, the employees there would comprise chiefly, I suppose, a board of engineers for direction?

General DAVIS. That is all; and inspectors.

Senator MORGAN. And a corps of engineers for inspection?

General DAVIS. Yes, sir.

Senator MORGAN. And reports, and all that?

General DAVIS. Yes.

Senator MORGAN. And, then, of course, an office of audit?

General DAVIS. The auditor of the Government here in Washington ought to be sufficient.

Senator MORGAN. And a paymaster's office?

General DAVIS. Well, yes; there would be a local disbursing officer down there, but he would not have very much money to disburse there.

Senator MORGAN. He would only have to pay the employees of the Government?

General DAVIS. That is all. The contract payments would all be made here by the Treasury Department in Washington.

Senator MORGAN. And in a case of that kind we could get rid of all questions of supplying finances?

General DAVIS. Oh, yes; we would not have anything to do with finance at all.

Senator MORGAN. But it would be very important, I should think, in the event that we let out the contract to one contractor or to many, that the United States should, by positive enactment, establish a fiscal system down there.

General DAVIS. I think there ought to be something definite about what the circulating medium shall be.

Senator MORGAN. It ought to be under the control of the Government of the United States?

General DAVIS. Well, yes; I should think so.

Senator MORGAN. And not a partnership with Panama in any respect?

General DAVIS. No; I do not see any need of it. I do not see any need of having but one direction.

Senator MORGAN. Do you think that it is safe, in the construction and control of that canal work, at least up to the time of its completion, that there should be any joint interest between the Government of Panama and the United States in that Canal Zone?

General DAVIS. I do not think there should be any joint responsibility. I do not think there should be any intervention or any power of intervention. As the United States possesses all the powers that a sovereign could exercise, to the entire exclusion of those powers by the Republic of Panama, I see no basis for any partnership; but I think it is highly important that they should be good neighbors.

Senator MORGAN. And there should be a good understanding between them?

General DAVIS. That there should be harmony and pleasant relations.

Senator MORGAN. Mutual assistance?

General DAVIS. Yes, sir; this business of chasing criminals—extradition—is beset with difficulties. When I was governor of the Zone all that I did, and all that the head of the Government of the Republic did in regard to extradition, was simply to turn over the criminals, one to the other, and say nothing about it. We did not have any protocols or agreements or treaties or anything. They said: "Here is a fellow that has escaped over into the Zone, and we want him; can't we get him? He is charged with having committed robbery, or something;" and if the chief of police could pick him up we turned him over to them; and they did just the same for us.

It was entirely a matter of perfectly voluntary work. Each assisted the other. There was a good deal of cattle stealing from outside of the Zone, and they would try to run the cattle into the Zone, have them slaughtered, and have the meat sold there. I always assisted the Panama authorities in catching those thieves if we could; and did everything I could to simplify it, and they responded. It is quite important that we should be on good terms with the Panama authorities, and it is easy to be so. There is no difficulty about securing such an entente cordiale.

Senator TALIAFERRO. Are there many cattle on the Isthmus?

General DAVIS. No; very few; you might say almost none; but there are a good many in the Republic outside.

Senator KITTREDGE. I think Senator Taliaferro is speaking of the Isthmus.

General DAVIS. Oh, in the Isthmus—in the Republic—I have not the basis of getting accurate information about it, but I have heard people say that in the Republic of Panama out towards Chiriqui and in that direction there are 200,000 or 300,000 head of cattle. I have heard the number stated at 200,000 or 300,000. They are brought into the Zone and slaughtered there continually.

I think Senator Kittredge has seen them. They are nice, sleek, smooth, well-conditioned animals, small in size, of light color and thin hair. I have eaten their meat, and it is very good. It is not abundant, but it is wholesome. Mules and horses are few and scarce and expensive. The market for horses is South America, principally Chile. Some of the mules that we are using there now in hauling, drayage, and cartage are mules that were raised in Chile, and they are very nice animals.

Senator MORGAN. I will not ask the General any further questions, although the field opened before me is a very inviting one; but I think we have perhaps gone far enough.

General Davis was thereupon excused, with the thanks of the committee; and after an executive session the committee adjourned until to-morrow, Tuesday, April 3, 1906, at 10.30 o'clock a. m.

**WRITTEN STATEMENT OF B. M. HARROD
ON TYPE OF CANAL.**

Written statement of B. M. Harrod, esq.

The lake idea is logically connected with a lock canal. A lock canal is not built for the sake of the locks. They, per se, are objectionable, unless they provide compensating advantages in the lakes they form. The lock-canal advocates had in this case the opportunity of developing the lake idea, or an unobstructed navigation to the greatest extent, so as to present for 29 out of the 41 miles between the shore lines of the Isthmus a channel, ideal in width and depth, practically equal to navigation in the open sea. On the other hand, the sea-level advocates have been forced by circumstances connected with time and money to reduce their channel throughout to the least possible dimensions—in fact, to dimensions which do not comply with the strict injunctions of the act of Congress.

The sea-level canal, as designed, will not “afford convenient passage for vessels of the largest tonnage and greatest draft now in use and such as may be reasonably anticipated.” The dimensions of the project will not allow vessels even now building to pass each other. Ships of average size can not pass each other without one stopping and tying up, but for this no spaces or “gares” are provided. Neither is there any widening of channel proposed at curves. These conveniences, or rather necessities, can be readily provided, but only with considerable increase in the estimates for both construction and operation. The demand for enlargement will be heard as soon as the inadequacy of the proposed dimensions is developed by operation.

It is proposed, during the construction of a sea-level canal, to conduct the Chagres and its eastern tributaries to the Caribbean Sea through diversion channels. These have been partially excavated by the French, but many million cubic yards of excavation and embankment are required for their completion. Until the Gamboa dam is completed they must have capacity for the flood discharge of the Chagres and its tributaries. After the canal is completed the Chagres will be regulated by the Gamboa dam, and all its tributaries, except the Cano and Gigante, will be turned into its prism. These two will be dammed and diverted in another direction. There will therefore be in the canal a current toward the Caribbean varying, according to the discharge stage of the rivers, estimated at from 1 to 2½ miles per hour.

Of the tributaries to be received into the prism of the canal there are 22 of considerable size. Two are known to have a flood discharge of over 3,000 cubic feet per second; eight more have discharges of over 1,000 cubic feet per second. Their flood discharges between Gamboa and Bohio may aggregate 30,000 second-feet. They descend into the canal from heights varying from 13 to 160 feet above sea level. The sea-level plan proposes to overcome this difference of level by masonry-stepped aprons, metallic pipes, or by sloping and lowering the beds of the influent streams, although no designs are presented. Professor Burr in his testimony describes basins at the mouths of these streams, to strain out the sediment and débris, allowing only the water to enter the canal, but that is a personal suggestion and does not appear in the plan. This would certainly add materially to the estimate, and it is doubtful whether it would not be more costly to clean out the several basins, which would rapidly fill up, than to dredge the deposit from the canal itself.

I believe that the discharge of 3,000 cubic feet per second into the canal prism of 8,000 feet cross section would cause cross currents which would prove an absolute obstruction to navigation as long as they prevailed. No ship could hold a direct course under such conditions. She would be driven against the opposite bank. Even lesser discharges would prove proportionately obstructive to navigation.

I believe that the injection of 3,000 cubic feet per second into a canal prism of only 8,000 or 10,000 square feet of sectional area would cause deposit on one side and would abrade the opposite bank unless it were in rock, and that these effects, in combination with a current varying from 1 to 2½ miles per hour would give to those parts of the projected sea-level canal through earthen banks the characteristics of an alluvial stream which would ultimately establish meanders or sinuosities that would seriously impair the navigability of the canal for all larger ships, unless these banks were artificially protected, and the bars constantly dredged.

It is proposed in the sea-level plan to divert the Cano, Gigante, and Gigantito from the canal route by four dams and a spillway. These are all in a region of which little is known by survey. The largest of these dams holds a head of water about 70 feet above sea level, only a few feet less than the Gatun dam, and is about 3,000 feet long. No intimation is given of the method of construction, whether of earth, masonry, or a combination of the two.

The estimate for completing 21 miles of temporary diversion and of several miles of permanent diversion, aggregating many million yards of excavation; for controlling the descent of twenty or more tributaries, by masonry structures, into the canal, and for the building of four dams and a spillway, for which no plan is proposed, in a region where no investigation of foundations has been made, is three and one-half millions plus 20 per cent, which I believe will prove entirely inadequate.

I prefer the Gatun to the Bohio location for a dam because the foundation is more impervious; because the site at Gatun admits of three locks of the required size, while that at Bohio will not hold two of the same length; because it is doubtful if the supply of water at Bohio is sufficient with the larger locks for a traffic of more than 10,000,000 tons, while at Gatun it is sufficient for 40,000,000 tons,

and because the Gatun location affords 10 miles more of absolutely unobstructed navigation.

I have confidence in the absolute stability and sufficient impermeability of the Gatun dam as designed. The experiments made and recited by Mr. Stearns and Mr. Noble give a scientific basis to such an opinion. It is not an engineering guess, in the present state of knowledge, to claim that percolation may be reduced to almost any extent by the increase of resistance through additional material and by the reduction of the hydraulic gradient.

My experience with the levees of the Mississippi River, with which I was connected for twenty-six years as engineer for the State of Louisiana, and afterwards as a member of the Mississippi River Commission, confirms me in this view. These structures deal with the same problems of the stability of the embankment, and seepage through the foundations as does the Gatun dam. There are levees there holding heads of water up to 40 feet, with bases of only about eight or ten times the pressure height, and back slopes of one on five or six. They are proved safe by experience. The Gatun dam, as designed, has a base thirty-one times the pressure height and a back slope of one on twenty-five. In the great Mississippi River flood of 1882, when the levee system was in its worst state, entirely inadequate in both grade and section, there were in a certain district over 140 breaks, of which every one but two was caused by the water overtopping the levee crest, and the remaining two by unknown causes, probably burrowing animals. Neither of these causes can affect the Gatun dam with its height of 50 feet above the lake and its thickness of 374 feet at the water line.

B. M. HARROD.

REPORT
OF THE
ENGINEERING COMMITTEE,
FEBRUARY 14, 1905.

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ISTHMIAN CANAL.

REPORT OF ENGINEERING COMMITTEE.

ANCON, ISTHMIAN CANAL ZONE,
Executive Office, February 14, 1905.

SIR: The committee on engineering of the Isthmian Canal Commission sailed from New York on January 17, 1905, and arrived at Colon on January 24. Under resolution of the Commission, Maj. Gen. George W. Davis, governor, became a member of the committee during its stay on the Isthmus, and acted continuously in that capacity until its departure.

The committee began its duties immediately upon its arrival, and held its sessions and conferences daily at the office of the governor, except when engaged in examinations of the actual or proposed work along the canal line.

The chief engineer of the Commission laid before the committee the entire data collected by the engineering field parties of his force, and such maps, plans, and other records as had been prepared in his office up to the departure of the committee. He was also in attendance at the meetings and conferences of the committee and on the field examinations, which included visits to all the parties on the entire line, as well as to all points of interest and importance in connection with the work.

The interior harbor at the Cristobal entrance to the canal and the adjoining works received early consideration from the committee, because extensive harbor accommodations are urgently needed at once to serve ships there in discharging plant, materials, and supplies for the construction of the canal. These needs are already pressing, and they will rapidly increase and become far more pressing in the near future.

The committee examined in detail the site of this interior harbor, as well as the entire water front of Colon, on Friday, January 27, while a severe norther was blowing, and its members were thus fortunate in viewing conditions bearing most impressively on the design and construction of the necessary works at the Atlantic end of the canal.

The norther began blowing soon after noon of January 26 with such force that three steamships in the harbor of Colon at that time were compelled to seek safety by putting to sea and remaining away for three days. The U. S. S. *Dixie* was preparing to leave at about that time, and was obliged to hasten her departure to escape the danger of the storm. Not a vessel of any description remained in the harbor except two schooners in the slips adjacent to the Panama Railroad

station, which were tied by a number of cables at a sufficient distance from their piers to prevent damage from excessive pitching and rolling. They could not get away, and were compelled to ride out the gale in grave danger to themselves and to the neighboring piers.

At the time of the committee's visit, storm waves of great magnitude and force were rolling directly into the harbor, breaking over the entire water front of that part of Colon known as Aspinwall, and blocking the marginal streets with deluges of water and great quantities of coral rock and other débris. The same effects were produced on Cristobal Point, seriously injuring a number of houses and rendering them uninhabitable, as well as putting out of use the marginal street. The magnitude and violence of the wave action along the entire water front of Colon not only drove to sea every vessel that could get away, but it also endangered the piers or wharves, some of which have been heretofore seriously damaged in similar storms. Further than this, great inconvenience and some loss was caused, not only to the shipping interests affected, but also to the canal work in interrupting the discharge of cargo urgently needed, and in other ways injuring Isthmian transportation.

These storms occur on the average but once or twice a year, and during some years they do not occur at all. For probably not less than three hundred and sixty days in the year the harbor of Colon is free from any objection of this kind. If the construction of the canal were a purely commercial enterprise, the protection of an outer terminal harbor open to storms at rare intervals, as in this instance, would not be justified. This project, however, is a great public work by the United States Government, in which no feature contributing effectively to either safety or efficiency should be omitted.

It is, therefore, the unanimous and unqualified judgment of the committee that a harbor directly open to such heavy storm seas as to drive out shipping and endanger water-front structures, even if the storms occur on the average but once or twice a year, is clearly unsuitable even for the outer harbor at the entrance of the Panama Canal where many ships must from time to time necessarily lie at anchor.

For these reasons the committee unanimously recommend that plans and specifications be at once prepared for a breakwater extending across the mouth of Limon Bay approximately on the line drawn from the light on Toro Point to the Colon light. This breakwater will probably be designed in two parts, each about 4,000 feet long, with an opening between them 700 to 800 feet wide for the entrance of ships.

It is the judgment of the committee that the construction of that portion of the breakwater nearest to Colon should be commenced at the earliest practicable date. This would insure a substantial measure of protection in the near future for the piers and wharves of the Colon water front where ships may at all times transfer cargoes in safety. The remaining portion of the breakwater could then be constructed, if experience should show it to be necessary, or it can be omitted if there should prove to be sufficient harbor protection without it.

The rock required for the breakwater can be obtained of proper quality and in any desired quantity from the deep portions of the summit cut of the canal between Obispo and Culebra, from the quarry at Bohio, and from Kenneys Bluff on the west shore of the Bay of Limon. The hard rock of the summit cut is well adapted to the

requirements of the superstructure. The cost of quarrying is not, therefore, an element of cost of the breakwater.

The interior harbor at the entrance of the canal immediately south of Cristobal Point, as proposed by the New Panama Canal Company, is urgently needed, even at this time. Temporary timber pile wharves at Cristobal and adjacent to the entrance to the dry dock, half a mile farther south, have already been completed and used, but they are of small capacity, and there is insufficient depth of water in front of them. This harbor and the channel from the outer bay should be dredged at once, and substantial timber quays or wharves should also be constructed immediately.

At its meeting on February 1, this committee unanimously passed the following resolution, as shown by the minutes of its meetings accompanying this report:

1. *Resolved*, That the committee approve and recommend to the Commission 30 feet as an immediate depth for the inner harbor at Cristobal and approach thereto, beginning at the 30-foot contour in the outer harbor, and extending thence to station 51, where it appears that indurated clay will be met at that depth. The width of approach channel should be about 500 feet, and that of the inner harbor about 1,000 feet, except as narrowed at the north end of Mangrove Beach Island, to reduce coral rock excavation, and widened at turn to make a basin.

This harbor, so constructed as to bring conveniently along its quays the tracks of the Panama Railroad, will be of the greatest value during the entire progress of the canal work.

In order to cover all possible contract work which it may be desirable to undertake along the approach channel and interior harbor heretofore contemplated as parts of a finished canal and entrance harbor, this committee, at the same meeting of February 1, unanimously passed the following resolutions as expressing further recommendations to the Commission:

2. *Resolved*, That bids be invited for dredging from the outer harbor to station 51 on the widths as in the preceding resolution, and from station 51 to station 100 for a width of about 1,000 feet, all at depths of 30, 35, and 40 feet.

3. *Resolved*, That the material be classified as—

- (1) Coral and other rock;
- (2) Indurated clay;
- (3) Sand and mud;

and that bids be asked for delivering material excavated by pumping at any point within 2,000 feet, as selected by the engineer, and with extra prices for each 1,000 feet in addition. Hard material shall be carried to and dumped at sea within a maximum distance of 3 miles from Cristobal Point, as directed by the engineer.

4. *Resolved*, That the chief engineer be directed to prepare the plans and specifications for the work, as indicated by resolutions Nos. 1, 2, and 3.

Although the interior harbor and approach channel as planned and recommended should be built immediately, it is the unanimous judgment of this committee that with the construction of the breakwater a direct entrance to the canal at or near Boca Mindi with a straight approach channel from the outer harbor has such substantial advantages that it should be adopted, independently of and in addition to the canal connecting with the inner harbor as heretofore planned. Ships may then proceed directly through the outer harbor into the canal, or into the inner harbor for coal or other purposes, and thence into the canal. The proposed direct entrance and approach channel are shown on the plans submitted herewith by the chief engineer.

The estimated quantities of material required to be excavated, or to be used for the construction of the breakwater, are as follows:

Common rock fill, 3,000,000 cubic yards.

Hard rock, 400,000 cubic yards.

At the present time the waters of the Gatuncillo River flow through a diversion channel south of Gatun into the Chagres River at that point. The combined flow of the Chagres and Gatuncillo is taken almost entirely into the channel of the former to the point where it cuts the canal excavation, a short distance north of Gatun, where the joint discharge divides, the larger part following the Chagres to the sea and the remainder flowing through the canal excavation to Boca Mindi, where it escapes through the enlarged mouth of the Mindi River into Limon Bay. The natural result has been the formation of a large bar, filling almost the entire canal channel immediately north of Boca Mindi. This action has been intensified when floods have filled the Gatuncillo and Chagres rivers.

The Old Panama Canal Company nearly completed what is known as the Gatuncillo diversion channel, located east of and mainly near to the canal line from the Gatuncillo River to Puerto Escondido in Manzanillo Bay. The continuation of this diversion southerly was partially excavated at numerous points from Gatun to Gamboa, easterly of the canal line, and it will probably have to be completed throughout that entire distance. Immediate attention, however, is directed to that portion already described and called the Gatuncillo diversion, which receives the waters of not only the Gatuncillo River, but also of the Mindi and other smaller streams flowing down from the high ground in that vicinity, and thus prevents them from entering the canal.

Whatever may be the final plans of the canal, or of its subsidiary works, this diversion must be completed and employed to discharge the waters it receives into Manzanillo Bay. The bottom width of the present excavation is about 115 feet, and it originally had a depth of water of about 15 feet. Silt and mud have now settled in it to a depth of one to three or four feet, leaving from ten to thirteen or fourteen feet of water. Two short stretches still remain to be excavated, one back of Monkey Hill, about 1,600 feet in length, of hard, indurated clay, and the other about 2,000 feet in length, mostly of mud, silt, and sand, near the Mindi River, where the railroad crosses its line; besides any enlargement of section that may be necessary.

Two small dams must also be constructed about 2,500 feet apart, across the Chagres River near Mindi, to retain within the diversion channel the waters which must not enter the canal. A diversion of the Chagres on the westerly side of the canal, in the same vicinity, must be retained to take the flow of the Chagres directly to the ocean. Another dam must be built across the Boca Mindi, on the line of railroad, to prevent the discharge of the Gatuncillo diversion through that opening which its waters now follow. These three dams and the Chagres diversion are necessary to complete the separation of the waters intended to flow through the Gatuncillo diversion and the Chagres River.

All the works thus far discussed are quite independent of the type or dimensions of the canal south of Gatun, and their construction is imperative; therefore, this committee unanimously recommends their immediate completion.

Before other subsidiary questions can be decided or even considered, a determination must be reached as to the elevation of the summit level. The plan of the French company, under which they were working, placed this level at 97.5 feet above mean tide, to be supplied with water from a storage lake at Alhajuela, which was also to regulate the Chagres. The former Isthmian Canal Commission considered a summit level at 85 feet, to be maintained by a large dam at Bohio, making a lake with an area of 38.5 square miles, and thus regulating Chagres floods.

When the present Commission was created it was realized that before a final determination could be made with propriety additional data should be obtained other than that possessed by the French company or secured by the former Commission, and especially that positive information should be had as to the probable cost of excavation, for on such cost, both as to time and money, will the type of the canal in large part depend.

Survey parties were at once established and contracts let for the installation at Culebra of a modern excavating plant.

The work of excavation in the summit or Culebra cut has been actively prosecuted under the direction of the chief engineer, so that the total quantity excavated during the month of January of the current year was about 71,000 cubic yards. The first three steam shovels of the 17 recently contracted for in the United States are now set up and at work, although the third one had not made a beginning of its work on the 1st of February. A shovel has exceeded a daily output of rock excavation of 1,000 cubic yards. The operations of the shovels have been entirely satisfactory, and they have already proved themselves to be machines of high efficiency. Indeed, the results so far obtained indicate that there is no other type of machine better adapted to the class of work to be done in the summit cut or which can reach a greater efficiency. The French excavators have also been put in a much more efficient condition, so that in clay excavation a single machine has also reached a daily output of nearly 1,400 cubic yards, but they are not well adapted to rock.

As a result of the experience thus far gained in the actual rock and clay excavation at Culebra, the average monthly cost per cubic yard has fallen below 50 cents. The chief engineer, therefore, is confident that the average cost of all the excavation in the summit cut will not exceed 50 cents per cubic yard, and this committee concurs in that opinion. The former Isthmian Canal Commission assumed in its estimates that the average cost of excavation in the great summit cut would be 80 cents per cubic yard. The demonstrated cost of this Commission's actual work at Culebra, if applied to the quantities employed by the former Commission, would reduce the total estimated cost of the canal about \$15,000,000. This large saving in cost makes a fundamental reconsideration of canal plans by this Commission essential. It is obvious that this actual reduced cost of excavation justifies a reduction in the elevation of the summit level of the canal by a correspondingly greater volume of excavation. After a careful consideration of all the elements of this portion of the canal problem this committee, as an expression of its judgment, passed unanimously the following resolution at its meeting on February 1:

7. *Resolved*, That the elevation of the summit level of the canal should not exceed 60 feet.

As will be seen by the accompanying report of the chief engineer, he has prepared full statements of estimated costs of construction of the canal for three different summit elevations:

1. With summit elevation at 60 feet above mean tide.
2. With summit elevation at 30 feet above mean tide.
3. A sea-level canal.

The total estimated costs of these three types of canal, including the breakwater, direct approach channel, and interior harbor at Colon will be:

Summit level at 60 feet elevation-----	\$178, 013, 406
Summit level at 30 feet elevation-----	194, 213, 406
Sea level -----	230, 475, 725

These totals include a margin of 20 per cent for contingencies, administration, sanitation, and engineering.

The effective control of the Chagres River, especially during its floods, which are frequently sudden and of great volume, has also been considered in all its relations to the plans of the canal which may ultimately be adopted. Inasmuch as the elevation of the water in the Chagres River at Gamboa is about 55 feet above mean tide, or but 5 feet below a summit level placed at 60 feet above mean tide, it is the judgment of this committee that the control of the Chagres River, with a summit level at an elevation of 60 feet or less, should be effected at or in the immediate vicinity of Gamboa, which the examinations made by the field party operating at that location and in the valley of the Chagres above Gamboa show to be entirely feasible.

For these reasons the committee unanimously passed the following resolution, expressing its recommendation to the Commission at the meeting of February 1:

8. *Resolved*, That in the event of the Commission approving resolution No. 7, that the Chagres River be retained by a dam located at Gamboa, and built to a crest height of about 200 feet.

The complete data secured by the surveys and examinations of that field party are given in the accompanying report of the chief engineer. They show that the high hills on both sides of the river at Gamboa, in connection with the maximum depth of bed rock in the river, about 56 feet below low water, render the construction of the dam across the Chagres at this location, with the attendant works of pipes and gates and waste weir, reasonably free from serious difficulties, and bring construction within reasonable cost. Surveys show that the area inclosed within the flow line of the lake formed by this dam for the elevation of water surface at 200 feet above mean tide, would be 43.3 square miles; at the elevation of 170 feet, 30.8 square miles; and at the elevation of 132 feet, 14.9 square miles.

Accurate flood records for the Chagres River have been kept during the past thirteen or fourteen years only. The greatest flood which has occurred since the beginning of the construction of the Panama Railroad in 1851 was that of 1879. No authoritative record of the highest water, either at Bohio or at Gamboa, or at any other point, nor of the maximum discharge of that storm exists. The storm which caused this flood lasted about six days, and approximate evidence of its highest stage at Bohio is preserved in the memories of some persons now living. All the reliable information that can be ascertained has been used to determine approximately the greatest

rate of discharge of the Chagres at Bohio, which is supposed to have been about 136,000 cubic feet per second. It has further been concluded that the average discharge for forty-eight hours was about 112,000 cubic feet per second. While these results are approximate only, it appears that they may be safely employed for the determination of some general features of control. The results for Gamboa are somewhat less, both in rate and in total volume, than at Bohio. If an average discharge of 100,000 cubic feet per second for seventy-two hours be assumed at Gamboa, the resulting computations will certainly lead to safe conclusions regarding the capacity for control of the proposed Gamboa lake. If that amount of water flowed into the lake formed by the proposed Gamboa dam, with an initial water surface of the lake at an elevation of 160 feet, such a three days' inflow, with no outflow, would raise that surface not more than 30 feet, or to the elevation of about 190 feet. If, on the other hand, a uniform outflow of 20,000 cubic feet per second were maintained during the same length of time, the resulting rise of lake surface would be but a little over 20 feet, thus raising the elevation of that surface to slightly above 180 feet. The Gamboa lake, therefore, may be used in this manner as an effective control of the Chagres River, even during the highest flood which there is any reason to anticipate.

The greatest volume of continuous inflow into the lake which could take place under the authentic records of the past fourteen years is about 365,000 acre-feet per month for six consecutive months in 1892, and of 700,000 acre-feet for one month in 1894. A continuous outflow of not more than 10,000 cubic feet per second during these two periods of inflow would enable the lake to take care of both these periods of great discharge, without raising the surface of water more than a few feet and for a short period only.

While further detailed studies beyond those which were available to the committee on the Isthmus are required to determine the exact elements of this problem of the control of the Chagres during varying periods of high rates of inflow, the examination made by this committee shows conclusively that the lake proposed has sufficient capacity to afford abundant regulation of the Chagres floods.

The necessary rates of the outflow from the lake during flood periods may be obtained by means of large pipes and gates built into the dam itself, together with a waste weir at the same point, or by means of a tunnel about 3.4 miles long through the dividing ridge between the Chagres and Gatuncillo watersheds, or by both. The elevation of the invert of this tunnel at the Chagres end may be placed at 132 feet above mean tide. If such a tunnel were built at the elevation named, with a diameter of 30 feet, it could be depended upon to discharge 15,000 cubic feet per second, with the elevation of water surface between 180 and 185 feet, the mean velocity of water through the tunnel being about 20 feet per second. At least the same rate of discharge, and a greater one, if required, may be obtained through properly controlled pipes at the dam, discharging either into the canal or into a diversion channel on the easterly side of the Chagres River, constructed the entire distance to the Gatuncillo diversion, or into both.

Surveys for the location and estimate of cost of the tunnel for discharging into the upper waters of the Gatuncillo have already been

completed, as well as for a similar tunnel to discharge into the Pacific. Complete surveys are about to be undertaken to ascertain the exact amount of work which has been done on the Chagres diversions between Gamboa and Gatun, so as to make an accurate estimate of the cost of their completion. As soon as these latter surveys are completed the exact estimates of cost, both for the tunnel and for the diversion discharge, can be made, and all the details of these features of the regulation works can be determined.

Work on the foundation for the dam at Gamboa can be begun at once. This portion of the construction of the dam will probably require from a year to a year and a half of time, and it is the unanimous judgment of the committee that it should be undertaken immediately, and that the construction of the entire dam should be completed as soon as practicable.

The building of the dam at Gamboa will not only furnish complete and effective means of control for the Chagres floods, but it has the further advantage of being entirely accessible by the Panama Railroad for the transportation of men and materials. The plan of the dam will probably require a masonry core, with a great mass of earth and rock fill on either side of it, from the waste excavation of the summit cut. The plan, therefore, has marked merits of both efficiency of control and economy of construction.

The conditions attending the construction of this dam are in no way unprecedented. The depth of bed rock below water surface is only about one-third that at Bohio and no greater than has already been reached by the use of heavy timber sheet piling for founding masonry structures in the United States.

The proposed height of this dam from its foundation to its top is far less than found in a number of masonry dams already built, and the making of the earth embankments on the two sides of the masonry core is simply wasting the material from the summit cut. The construction of the Gamboa dam, therefore, involves no formidable obstacles not heretofore successfully encountered in engineering practice.

The practicability of certainly and satisfactorily controlling the floods of the Chagres by so simple and economical a method as the Gamboa lake and its outflow channels, and the reduced cost of excavation as actually demonstrated by the work of the Commission in the Culebra cut, makes the construction of a sea-level canal at a reasonable cost far more available than has heretofore appeared possible. These recent developments in the conditions attending the construction of the canal are so important as to be almost controlling in character. The remaining element is that of the time required to make the great summit excavation. It is to be carefully observed that the results thus far obtained in the Culebra cut have been reached under disadvantageous conditions of both organization of plant and force. The railroad tracks serving the excavators are yet fragmentary and tentatively placed to serve the purposes of investigation. In both respects the disposition of plant is far more unfavorable, both to economy and celerity of operations, than will be the case when a complete track system has been arranged and laid down to serve a large number of steam shovels operated by an experienced force. In the face of these disadvantageous conditions, the cost of excavation has

been reduced far lower than was anticipated, and it has been demonstrated that each steam shovel may be counted upon to yield an average record of at least 1,000 cubic yards per working day. The chief engineer estimates that with 100 steam shovels installed with a complete system of tracks serving them, a yearly record of 30,000,000 cubic yards of excavation may be reached without requiring a greater output per shovel, or a greater speed in working, than has already been attained. This rate of working could probably be reached within two years from the present time.

With the rate of progress which now appears reasonable to anticipate, this committee believes that a sea-level canal, with a tidal lock 1,000 feet long and 100 feet usable width, at Miraflores, can be completed within ten to twelve years from this time, the bottom width of the canal being 150 feet and the minimum depth of water 35 feet.

These considerations have induced this committee to express to the Commission its unanimous judgment that with the contemplated system of working, and with the rate of development which appears to be justified by the work now being performed at Culebra, a sea-level canal, free from the restriction of locks, should be adopted. This committee believes that such a canal, with terminal harbors, can be constructed for a sum not exceeding \$230,500,000.

The advantages of a sea-level canal across the Isthmus are most obvious. It would be a waterway with no restriction to navigation and which could easily be enlarged by widening or deepening at any time in the future, to accommodate an increased traffic, without any inconvenience to the shipping using it. Whereas, a lock canal is in reality a permanent restriction to the volume of traffic and size of ships that use it. Although it is possible to design and construct locks adapted to the future transformation to a sea-level canal, that transformation can not be made without serious inconvenience to navigation and at a cost so great as to be excessive. The additional cost of a sea-level canal over that of a canal with locks, with a summit level of 60 feet above mean tide, is \$52,462,000, or \$79,742,000 more than the estimated cost of the lock canal with a summit level 85 feet above mean tide, proposed by the former Isthmian Canal Commission, after allowing \$6,500,000 for the Colon breakwater and direct entrance not previously estimated. This committee considers this additional expenditure fully justified by the advantages secured.

This committee has considered most carefully suitable dimensions for the cross sections of the canal to be built. It has had in view the dimensions of the ship canals now built and in use, such as the Suez, the Manchester, the North Sea, and other similar waterways. The fact has also been carefully borne in mind that the city of New York is deepening its entrance channel to 40 feet. On the other hand, it is recognized that the depth of the Suez Canal is less than 30 feet, that the depth of the Manchester Canal is 26 feet, the North Sea Canal 32.8 feet, and the Kiel Canal 29.5 feet. It is also recognized that at the present time no loaded ship either enters or leaves the harbor of New York drawing more than about 33 feet. It is believed, therefore, that for many years the commerce seeking the Panama Canal will be amply accommodated by a depth of water not exceeding 35 feet.

In view of these considerations, this committee expresses its recommendation of the Commission by the following two resolutions, unanimously passed in its meeting of February 3:

9. *Resolved*, That 150 feet be recommended as the minimum bottom width.

10. *Resolved*, That 35 feet be recommended as a minimum depth, but that estimates be prepared for a depth of 40 feet as well.

If a canal with locks should ultimately be determined upon, this committee is of the opinion, in view of the restrictions which such structures impress upon a growing commerce, and in view, also, of the difficult and costly process of transformation to a sea-level canal under any practicable conditions, that the locks should be made of 1,000 feet usable length and 100 feet usable width, but fitted with intermediate gates so as to accommodate small ships with less consumption of water and less time required to pass the locks.

The borings along the sites proposed for the dam across the Chagres near Bohio have shown that bed rock is deeper than has been supposed at all the sites contemplated. The greatest depth to rock, both at the French site and on that tentatively proposed by the former Isthmian Canal Commission, is about 158 feet below sea level, and but little less at a third site a short distance upstream from the former, as shown by the borings thus far made. These results indicate greatly increased difficulties in the construction of any dam in the vicinity of Bohio. Further borings are now being made at a site near Buenavista, little more than half a mile above the French site, where the depth of bed rock seems to be at sensibly less depth. The investigations now in progress will soon be completed. Their completion is necessary to determine the most advantageous dam site in the vicinity of Bohio or Buenavista, if such a dam should be required. These borings, like others previously made in this location, have disclosed coarse, gravelly material, freely water bearing down to bed rock at many points, as well as occasional fragments of timber. This clearly indicates the necessity of cutting off subsurface flow along the deepest bed rock, in case a dam should be built at this location. These conditions are formidable because they are found at such great depths.

The surveys and examinations which have been made in regard to a possible dam site across the Chagres River at Gatun show that such a structure is not feasible. The width of the floor of the valley at that point is about 5,000 feet, and two borings made at what appears to be the most favorable section penetrated to a depth of 172.7 feet and 139.2 feet below sea level, respectively, without finding bed rock. Other examinations and borings have also been made at other sections of the Chagres Valley where a dam site seemed possible, between Gatun and Bohio, but with equally unfavorable results. It is clear, therefore, that it is not feasible to construct a dam across the Chagres River at any point lower down in its course than at Bohio.

As will be seen by the report of the chief engineer, the examinations made along the alternative line between Bohio and Gatun, known as the Tiger Hill cut-off, show that it will be costly to construct, and that for a considerable distance between Tiger Hill and Bohio it would be necessary to retain the water in the canal by embankments not less than 20 feet high, in some cases on soft ground. This committee is, therefore, unanimously of the opinion that it is advisable, both on the

score of economy and of safety of construction, to retain the present canal line between Gatun and Bohio.

At the meeting of this committee, held on February 14, the following resolution was unanimously adopted:

13. *Resolved*, That this committee approve and recommend for adoption by the Commission a plan for a sea-level canal, with a bottom width of 150 feet and a minimum depth of water of 35 feet, and with twin tidal locks at Miraflores, whose usable dimensions shall be 1,000 feet long and 100 feet wide, at a total estimated cost of \$230,500,000. Such estimate includes an allowance for administration, engineering, sanitation, and contingencies, amounting to \$38,450,000, but without allowance for interest during construction, expense of Zone government and collateral costs, and water supply, sewers, or paving of Panama or Colon, which last items are to be repaid by the inhabitants of those cities.

Respectfully,

WM. H. BURR.

WM. BARCLAY PARSONS.

GEO. W. DAVIS.

Rear-Admiral JOHN G. WALKER, U. S. N.,
Chairman, Isthmian Canal Commission,
Washington, D. C.

BRIEF SUMMARY OF TESTIMONY ON TYPE OF CANAL.

STATEMENT OF JOHN F. STEVENS.

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